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EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

MAY, 1923

COLD WAVES, NORTHERS AND BLIZZARDS IN THE UNITED STATES

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HARVARD UNIVERSITY

Beginnings of an Understanding of Cold Waves

"It will be readily seen that on the approach of a great storm from the lower latitudes by the usual routes, while revolving from right to left, its first effect will be to bring in the warm and humid air of a more southern region; and when the axis of the gale has passed, the contrary result necessarily follows. . . . Indeed, this rising of the thermometer during the access of winter storms, and its great depression as they pass off in their northeasterly courses, might in itself afford us good proof of the storm's rotation, were more direct evidence wanting." Thus, in 1846, wrote William C. Redfield, one of the brilliant group of American meteorologists of the middle and latter portion of the nineteenth century.[1]

The real beginning of an understanding of American cold waves is found in this statement. In July, 1861, in a remarkable letter written by Professor Joseph Henry, then secretary of the Smithsonian Institution, to General Sabine, the first use of the term *wave* occurs in connection with the advance of winter cold spells across the eastern United States. "We find that not only do the storms of wind and rain come to us (at Washington) from the west, and enter our territory from the north (near the Rocky Mountains, in British possessions, about 110° west), but also the cold and warm periods. The early and late portions traverse the country in the form of a long wave extending from north to south,

[1] William C. Redfield: "On three several hurricanes of the Atlantic and their relations to the northers of Mexico and Central America, with notices of other storms," 8vo., New Haven, Connecticut, 1846, pp. 102, 104. The papers collected in this publication first appeared in the *American Journal of Science*.

and moving eastward. When this wave arrives at a given meridian during the night, a killing frost is experienced along a band of country extending north and south, it may be in some cases more than a thousand miles, while in an east and west direction it is not more than fifty or a hundred miles."[2] "From the observations made at this institution," Professor Henry further said, "the waves, as it were, of cold which reduce the temperature of the United States frequently begin several days earlier at the extreme west."[3] Further, speaking of a forthcoming volume of meteorological observations to be published by the institution, the secretary said: "This volume will also contain special thermometric observations at stations distributed over the area extending from the Arctic regions to the northern states of South America; and from the Pacific to the Atlantic coast, for the purpose of showing the progress of cold periods across the continent, from the Rocky Mountains to Bermuda."[4]

Thus, a decade before the publication of the first regular daily weather maps for the United States, the eastward progression of *waves* of cold from the Rocky Mountains to the Atlantic coast was clearly recognized. Indeed, as far back as 1793 emphasis was laid on the greater frequency and severity of winter cold spells in New England than in corresponding latitudes in Europe, although the low temperature was wrongly attributed to the descent of the northwest winds from the Appalachian Mountains, and there was, naturally, no recognition of the cyclonic control over these winds.[5] The importance of cold waves in relation to agriculture, transpor-

2 The present writer has been unable to find either the original letter from Professor Henry to General Sabine, or the first printing of it. Through the courtesy of Dr. Charles D. Walcott, the present secretary of the Smithsonian Institution, a search was made and no record was found of the letter, which may have been destroyed with practically all the other records of the institution in the fire of 1865. The meteorological material at the Smithsonian Institution was later turned over to the Signal Office of the United States Army, after the establishment of the government meteorological service in 1870. Professor C. F. Talman, librarian of the United States Weather Bureau, has very kindly made a search through the files of the Bureau, but without success. The quotation here given is taken from Fitz Roy's "Weather Book" (p. 137), where Professor Talman informed the writer that the letter was printed. Curiously enough, the letter is not found in the two volumes of Henry's scientific writings, published in 1886 by the Smithsonian Institution.

3 *Ann. Rept. Smithson. Instn. for 1861*, Washington, D. C., 1862, p. 20.

4 *Ibid*, p. 37.

5 Samuel Hale: "Conjectures of the natural causes of the northwest winds being colder and more frequent in the winter in New England than in the same degrees of latitude in Europe," *Mem. Amer. Acad. Arts and Sciences*, Vol. 2, 1793, pp. 61-63.

tation and other interests has naturally led to a considerable study of these phenomena, chiefly from the point of view of the forecaster.[6]

Definition of a Cold Wave

Not every considerable and sudden fall of temperature in the United States is a cold wave. For forecasting purposes it is necessary to define certain limits, both of time and temperature-fall. A cold wave, according to the official definition adopted by the U. S. Weather Bureau, is a drop of a certain number of degrees of temperature within 24 hours, with a minimum falling below a fixed temperature. The amount of drop, and also the minimum, are different for different sections and for different seasons, the definite values in each case having been arbitrarily fixed with a view to securing the best possible protection for agricultural and commercial interests.

Figure I shows the required temperature falls (within 24 hours) and the minimum temperatures necessary to give a cold wave,

[6] Lists of notable cold waves may be found in Lorin Blodget, "Climatology of the United States," 1857; A. W. Greely, "American Weather," 1888 (pp. 216-222); and E. B. Garriott, "Cold waves and frost in the United States," *United States Department of Agriculture Weather Bureau Bulletin P. 4°*, Washington, D. C., 1906, pp. 22, chs. 328. The last named publication "notes briefly the general distribution of the colder areas of the northern hemisphere, refers to general conditions that are associated with cold waves, and presents a chronological account of historical cold periods in the United States. It then summarizes and classifies the more important cold waves and frosts that occurred from 1888 to 1902 inclusive, and presents 328 charts that exhibit the meteorological conditions that attended the principal cold waves of that period." Reference may also be made to Alfred J. Henry, "Climatology of the United States," *United States Department of Agriculture, Weather Bureau, Bulletin Q 4°*, Washington, D. C., 1906, and, for a recent discussion of cold wave forecasts, to "Weather forecasting in the United States," by a board composed of Alfred J. Henry, chairman, Edward H. Bowie, Henry J. Cox and Harry C. Frankenfield, *United States Weather Bureau, No. 583*, 8 vo., Washington, D. C., 1916. Professor H. J. Cox contributes the general discussion of cold waves (chap. VI, pp. 143-176), which is illustrated by weather maps typical of various cold wave conditions. Fig. 66, p. 148, shows the number of cold waves which occurred between 1904 and 1914 inclusive. There are also shorter papers by the district forecasters on the cold waves of the different sections. The *Monthly Weather Review* regularly contains discussions of cold waves as they occur, often illustrated by special weather maps. Several pamphlets issued by the United States Department of Agriculture have discussed the subject of frost and of cold waves and have indicated methods of protection against frost and cold. See, *e.g.*, E. B. Garriott, "Notes on frost," *United States Department of Agriculture, Farmers' Bulletin 104*, 8 vo., Washington, D. C., 1899; revised by A. G. McAdie, August, 1911. An early publication on cold waves is T. M. Woodruff, "Cold waves and their progress," United States Signal Service Notes No. 23.

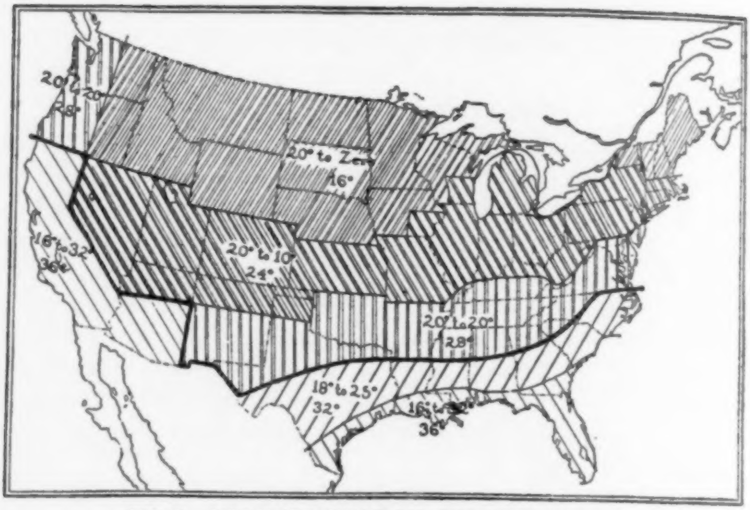

FIG. I. COLD WAVE CHART FOR THE UNITED STATES.

according to the official definition of the U. S. Weather Bureau. The upper figures are for winter; the lower for the other months. Above the heavy line the winter months include December, January, February and March; below it, December, January and February. It is to be observed that the cold wave is simply a certain condition of temperature, and the definition has nothing whatever to do with the wind. In the popular mind, however, the wind which brings the cold and the cold itself are always thought of as constituting the cold wave. The amounts of fall of temperature are the same in all seasons for each individual district, but the limiting minima vary, being lower in winter and higher during the rest of the year. These minima, furthermore, are not as far below the normal in the north as in the south. Along the Gulf and southern Pacific coast, for example, where crops are growing the year round, temperatures below freezing are dangerous at any time. The limiting temperatures being but slightly below the normal in the north, and much below normal in the south, the number of cold waves recorded in the north is naturally much greater than that recorded in the south. The cyclonic conditions favorable for cold waves are also more frequent along and near the northern border.

General Description of a Cold Wave

For severity, suddenness and frequency of occurrence the cold waves of the eastern United States are unique. They are typically American phenomena. As first pointed out by Redfield, they are a characteristic feature of the rear of winter cyclonic storms, and

follow warmer weather, accompanied by winter rains or snow, in front of the low pressure center. Following the passage of the centre, especially when there is a well-developed high pressure area in the northwest and the wind-shift line is well developed, the cold wave is heralded by a sudden shift of the wind to the west and northwest—a piercing blast, sweeping down from the cold continental interior of western Canada, reducing the temperature 20°, 30°, 40°, or even more, within 24 hours. The drop in temperature often begins before the rain or snow has ceased falling. If it is still raining when the westerly wind begins to blow, the rain quickly turns to sleet, and an icy covering forms on all objects outdoors. If it has been snowing, the snow soon becomes hard and dry. The wheels of passing vehicles, the runners of sleighs and the footsteps of pedestrians "sing" with a metallic sound. The ice on rivers and lakes tightens its grasp, and cracks and "booms" with a reverberating sound. The collars of great coats are turned up; hands are put into muffs or pockets; people walk more briskly; every preparation is made for a spell of hard cold weather.

The northwest wind blows with considerable velocity for a day or more, accompanied by clear skies and bright sunshine, and then gradually diminishes. While the cold is more keenly felt during the blowing of the strong wind, the actual minimum temperatures are recorded on the two or three, or perhaps more, calm, clear nights which follow, in the central portion of the anticyclone. Under these conditions, nocturnal radiation fogs are common. The cold wave proper is, therefore, not at the center of the high, but on its southeastern margin and to the southwest of the preceding low, in the area occupied by the northerly and northwesterly winds.

From their northwestern origin the areas of cold, usually more or less elliptical in shape with the longer axis extending southwest-northeast and covering hundreds of thousands of square miles in extreme cases, progress in a general easterly or southeasterly direction towards the Atlantic or Gulf coasts, but with much diminished intensity, as they enter warmer latitudes and increase their distance from their frigid northern source. In Figure II the "cold wave axis" shows the middle frontage of cold waves as they come down from the northwest in the winter months, as plotted by Professor F. H. Bigelow.[7] The axes of certain characteristic types of individual cold waves, greatly generalized, are indicated (fol-

[7] F. H. Bigelow: "Storms, storm tracks and weather forecasting," *United States Weather Bureau, Bulletin 20*, 8 vo., Washington, D. C., 1897; reproduced in the *Atlas of Meteorology*, Pl. 28.

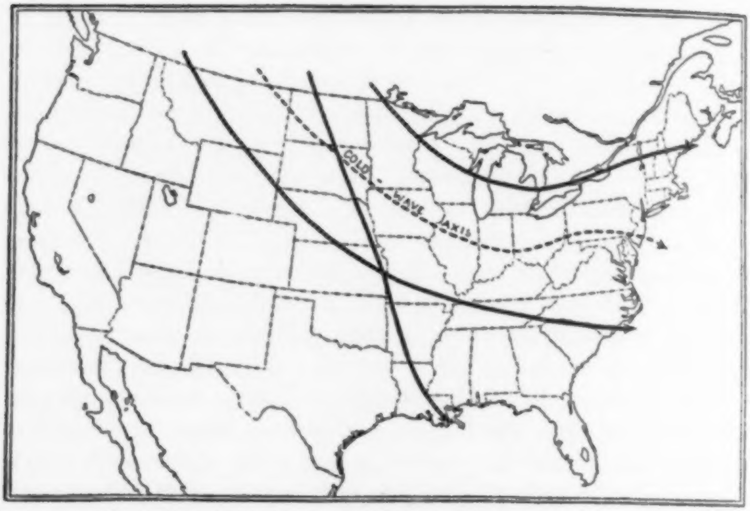

FIG. II. COLD WAVE AXIS AND GENERALIZED PATHS OF COLD WAVES ACROSS THE EASTERN UNITED STATES.

lowing J. P. Finley) by the broad lines, the direction of progression being shown by the arrow-head. The rate of advance is determined by the rate of progression of the controlling cyclonic and anticyclonic pressure systems. A cold wave may easily sweep over the country from the northern plains to Texas or to the Atlantic coast in two or three days. As it advances, it gradually becomes less severe, especially (1) if the ground is not snow-covered; (2) in the early spring, and (3) during the daytime, when the increasing warmth of the sun is able to warm the earth's surface more effectively. The lower air may then become more or less unstable. Convectional overturnings, flurries and eddies occur. The wind blows with a somewhat higher velocity during the day. If, on the other hand, the northwest wind blows at night over a snow-covered surface, the temperature of the lower stratum may be somewhat reduced as the cold wave sweeps forward on its course.

It is fairly safe to expect, on the average, three or four severe cold waves every winter in the eastern United States, but such intense cold spells do not, as a rule, last longer than two or three days except over the northern plains, and are naturally more frequent in the north than in the south. After about the middle of February the duration of these "cold snaps," as they are often popularly termed, usually lessens perceptibly. Conditions similar to those which produce the cold waves of winter, but far less marked, prevail also in summer. The clearing northwest winds in the rear of a passing summer cyclonic storm, or after a well-developed wind-shift line thunderstorm, are pleasantly cool, dry

and refreshing, following, as they do, a spell of muggy and oppressive heat which has accompanied the southerly winds on the front of the low. These summer "cool waves" therefore give welcome relief during the hot months, and are an important factor in making the climate of that season more agreeable and more healthful.

Factors Favorable to Cold Waves

Several factors combine to produce the severe cold spells of the eastern United States. While the cold "wave" itself is directly due to the temporary pressure distribution, as will shortly be explained, the initial source of the cold is to be sought in the larger climatic conditions of the North American continent. During the long winter nights, under the prevailingly clear anticyclonic skies and in the dry air of the northern treeless continental interior, active radiation from the lower atmosphere, both to ground and sky, reduces the temperature to very low readings. These fundamental conditions doubtless supply most of the cold, which is then imported to lower latitudes.[8] The permanent winter high pressure conditions over the northern portions of North America accelerate this flow of cold air, which is most active when a well-developed anticyclone follows the retreating cyclone. In addition, the original cold is reinforced and more or less effectively maintained by the active radiation which takes place in the dry clear air of the western quadrants of the cyclone and of the following anticyclone, as these move eastward across or along the northern border of the United States. This local reduction of temperature during the advance of the cold wave is especially effective when the ground is covered with snow. The minimum temperatures, as has just been indicated, are not recorded during the active blowing of the northwest wind, but on the clear, calm anticyclonic nights which follow.

Another factor of essential importance in the production of American cold waves is the frequency, intensity and rapid progression of the winter storms. A further condition which makes the fall of temperature so marked is the presence of the warm ocean and Gulf waters to the south. Across these blow the warm southerly winds in advance of the low pressure areas, importing the high temperatures with which the succeeding cold is in such sharp contrast. There is, further, a series of topographic controls peculiar to North America. The Rocky Mountains constitute an effective barrier to the west. Hence cyclonic storms moving across

[8] See, *e.g.*, a discussion by Sir F. Stupart and the late Professor Cleveland Abbe on the origin of American cold waves in *Month. Wea. Rev.*, vol. 32, 1904, p. 113.

the Great Plains and then eastward can not readily supply their rear indraft from the west, and in place of that draw heavily on the reserves of colder air to the north. Further, this dry, cold, dense air finds itself moving with the general slope of the country down the Mississippi Valley towards the Gulf of Mexico and eastward towards the Atlantic, easily underrunning the warmer, lighter air on the front of the storm along the wind-shift line. The absence of any transverse mountain ranges across the great central lowlands leaves an unobstructed path for the cold waves to invade the whole tier of states bordering on the Gulf of Mexico. These temporary incursions of cold are one of the most serious climatic handicaps of the southern states from an agricultural standpoint. The long stretch of the Appalachian Mountains, paralleling the Atlantic coast, is not sufficiently high or massive to constitute an effective barrier against the advance of cold waves from the interior, although it does, not infrequently, furnish some protection to the southern Atlantic coast states when severe cold waves prevail to the west of the mountains.

Some Economic Aspects of Cold Waves

A climatic phenomenon marked and far-reaching in its economic effects is the cold wave. Many and varied are the ways in which it affects man and his multitudinous activities and interests, as the Weather Bureau has often pointed out. When a cold wave is on the way, heating plants, whether steam, electric or natural gas, are prepared for an increased demand, and individual heating systems and furnaces are run at full blast. Greenhouses are closed and kept at a higher temperature. Fire-plugs and exposed water pipes are protected. Gasoline engines out of doors are drained. The water in automobile radiators is mixed with alcohol or some other non-freezing liquid. Railway companies arrange for more heat in their passenger cars; accelerate the movement of perishable goods, and heat the cars containing them, or run these cars under cover for protection. The announcement of a cold wave is usually followed by hastened shipments of cold storage eggs from the western supply districts to the eastern markets, in anticipation of a rise in prices. On the other hand many goods are not shipped until the cold spell is over. Advertisements call attention to cold weather goods. Coal and wood dealers prepare for sudden demands for fuel. The dredging of sand and gravel ceases. Iron ore ready for shipment is protected so that it shall not freeze. Ice companies watch the increasing thickness of the ice forming in their supply reservoirs and decide whether to cut at once, or, if the cold is to be severe and prolonged, to wait for thicker ice.

Philanthropic organizations of all kinds prepare for sudden demands for fuel, food and clothing on the part of the poor. In districts where outdoor crops are exposed to the cold, and to frosts accompanying or closely following the advent of a cold wave, as in the citrus fruit orchards of southern California or the truck-gardens of the Gulf and southern Atlantic coasts, immediate preparations are made for adequate protection by means of thoroughly organized methods. In certain cases the crop may be saved from damage by being gathered in advance of the arrival of the damaging cold. In these, and in countless other ways, cold waves play a distinct part in the lives of many millions of people in the United States.

Instrumental Records of Cold Waves

A more vivid picture of the general characteristics of these sudden cold spells, which, of course, do not always meet the official definition of a cold wave, will be secured by a glance at the thermograph and barograph records obtained at a New England station. The temperature and pressure curves are supplemented by ob-

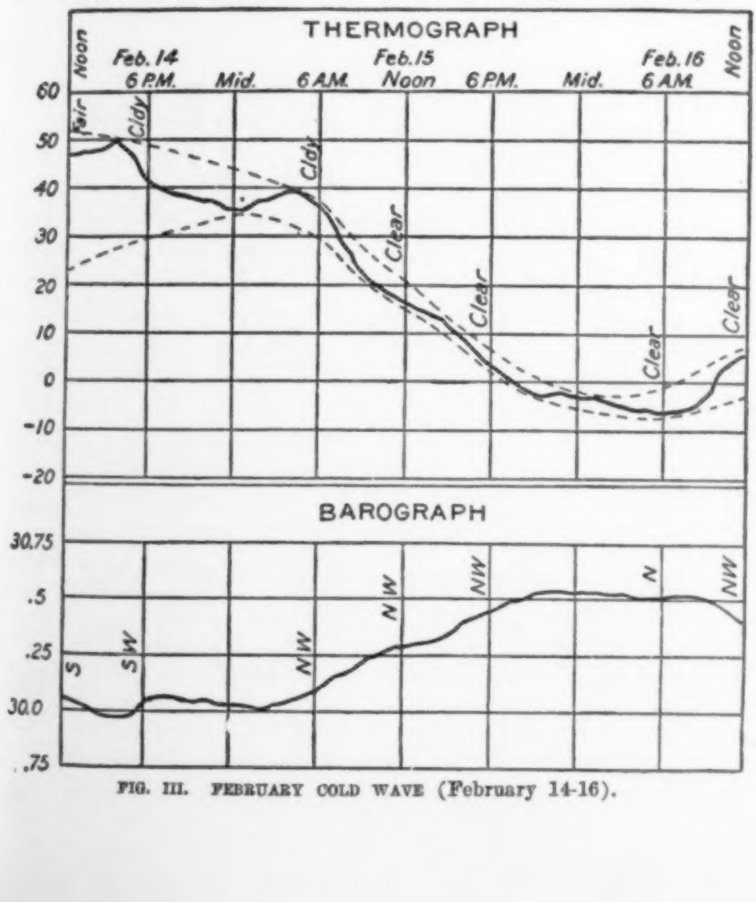

FIG. III. FEBRUARY COLD WAVE (February 14-16).

servations of the state of the sky and of wind direction. The conditions here represented are more or less typical for the whole area east of the Rocky Mountains, with modifications resulting from latitude and other controls. Figure III illustrates a February cold wave. A maximum temperature of 50°F. is reached under the warm, damp, muggy southerly winds of a winter cyclone passing by on the north. With a shift of wind into the northwest, as the wind-shift line passes the station, a rapid fall of temperature takes place from the early morning of one day (February 15), through noon, with practically no trace of diurnal warming although the sky is clear, to the early morning of the next day (February 16). The minimum (—5°) comes under the clear skies and light winds at the crest of the high. The cyclonic control of temperature is strikingly brought out in the drop of the temperature belt (enclosed by the broken lines) from one side of the diagram to the other. The fall in temperature was over 50° in 36 hours, and during all that time a strong biting northwest wind was blowing. Sudden temperature changes of this sort make it hard for persons who are not in robust health to endure the winters in the eastern United States. Figure IV is a good example of typical winter temperature changes under cyclonic and anticyclonic controls. A marked maximum of about 60° comes at the time of lowest pressure, under the control of the warm southwesterly winds and cloudy weather in association with the front of a winter cyclone passing by on the north (*cf.* Fig III, February 14). The two minima come at the crest of the two high pressure areas. On January 1 the minimum is at the initial midnight; the maximum is at the final midnight; the "diurnal range" is wholly cyclonic. On January

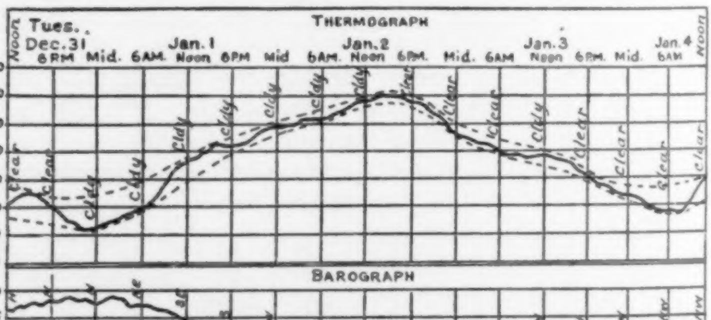

FIG. IV. TYPICAL WINTER TEMPERATURE CHANGES (December 31-January 4)

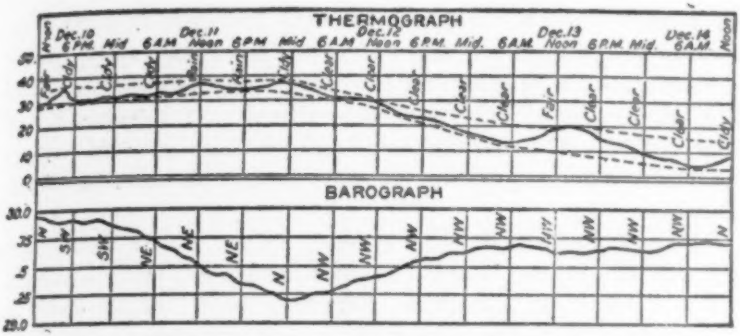

FIG. V. MODERATE DECEMBER COOL WAVE (December 10-14).

3 the maximum is at the initial midnight and the minimum at the final midnight. This is exactly the opposite condition, but the diurnal range of temperature is again wholly cyclonic. On January 1 and 2 the normal diurnal curve, with the maximum in the early afternoon and the minimum in the early morning, has completely disappeared under the more powerful cyclonic control.

In Figure V the rise of temperature in front of the approaching cyclone was only moderate (maximum under 40°), because of the blowing of rainy northeast winds (December 11) from the ocean. The fall of temperature under the northwest winds and

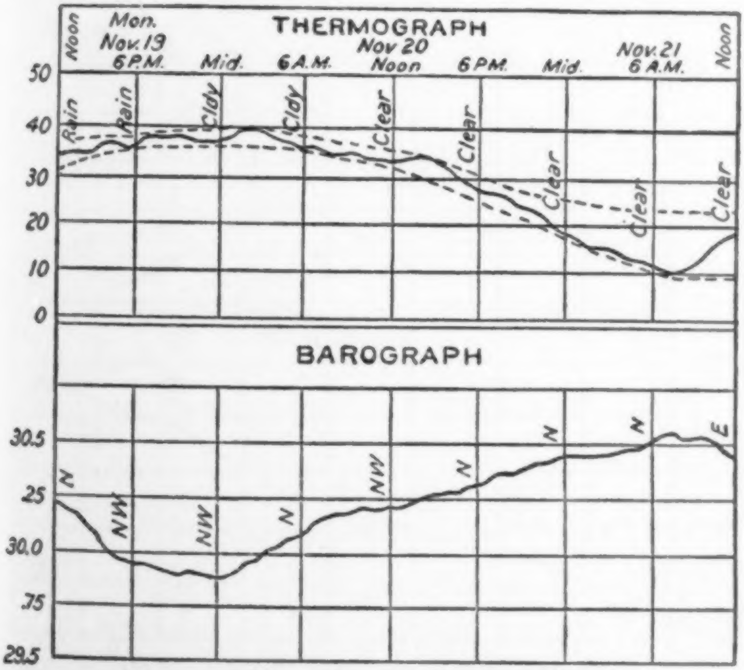

FIG. VI. NOVEMBER COLD SPELL (November 19-21).

clear skies of the succeeding anticyclone brought the thermometer down from between 35° and 40° to 5°, but rather slowly, as the pressure gradients were not steep, and the northwest winds of moderate velocity. The cool wave carried the temperature belt down, the downward slope being only slightly interrupted by a weak diurnal maximum under solar control on the afternoon of December 13.

During the autumn, the cyclonic control is less marked and the cold less severe. Figure VI illustrates a November cold spell. After a nocturnal maximum (November 19-20) of 40°, a fall in temperature beginning shortly after midnight continues over noon (November 20) and until early morning of the following day (November 21). Such a fall of temperature over noon is one of the characteristic signs of approaching winter. It shows the weakening solar and the increasing cyclonic control of the weather. The temperature belt is very narrow, showing slight diurnal ranges of temperature under the rain and the cloudy skies of November 19, and widens under the clear skies and light winds of the anticyclone (November 21). The minimum temperature (November 21) comes under the clear sky of the anticyclonic night, with very light northerly winds.

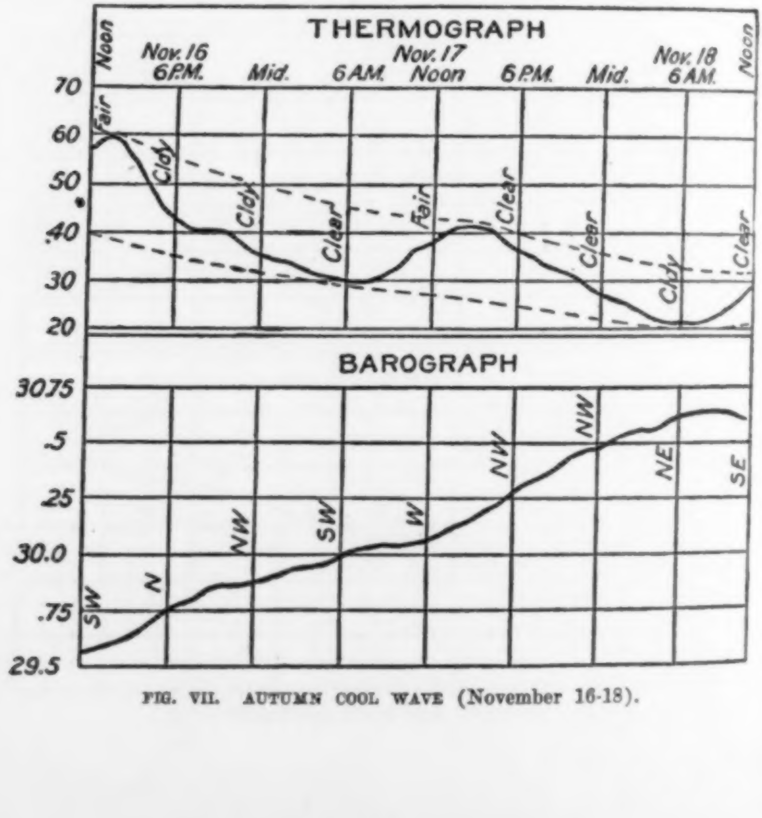

FIG. VII. AUTUMN COOL WAVE (November 16-18).

Another autumn cool wave is shown in Figure VII. The fall in temperature comes in front of an approaching anticyclone; the temperature belt is lowered as a whole, although the sun is shining. The winds, however, are not strong enough and the imported cold not severe enough to extinguish the normal diurnal range (November 17), with its afternoon maximum.

Weather Map Types Favorable for Cold Waves in the Eastern United States

Cold waves accompany well-developed areas of high pressure ("cold wave anticyclones") coming from the Canadian west or northwest and following behind cyclonic areas moving eastward in advance of them. The cold over western Canada may be very intense, but it can not advance far into the United States as a cold wave unless steep barometric gradients are present to make possible the draining off of the cold by the strong northerly and northwesterly winds blowing towards a cyclonic area to the south, southeast or east. As conditions of this sort occur much more frequently over the northern states than in the south, sudden marked temperature changes are most frequent in the north. The severity of a cold wave depends upon many factors. Among these are the intensity of the cold in the "cold wave high;" the size and the degree of development of this high; the pressure gradients; the relative positions, the paths and the rate of progression of the high and the low; the presence or absence of a snow-cover; the amount of cloud; the latitude; the month, etc.

When a large number of cold wave weather maps is examined, it is seen at once that the number of possible combinations of high and low pressure areas as to development, relative positions, paths, rate of progression, gradients, etc., is almost endless. A study of these type maps is of the utmost importance from the viewpoint of the forecaster. In the present discussion, however, which aims only to give the essential facts in their climatic rather than in their meteorological bearings, such details are quite unnecessary. The accompanying figures (VIII-X) are broadly generalized, free-hand composite maps which are intended to illustrate, in a very general way, weather map types which are associated with the occurrence of cold waves in the eastern United States. The sketch maps here reproduced are not copies of any weather maps, and they are not to be taken as representing pressure conditions which must be fulfilled in order that cold waves may occur. They are merely intended to illustrate, in a general way, the kind of pressure distribution which favors a flow of cold air from western Canada into the eastern United States.

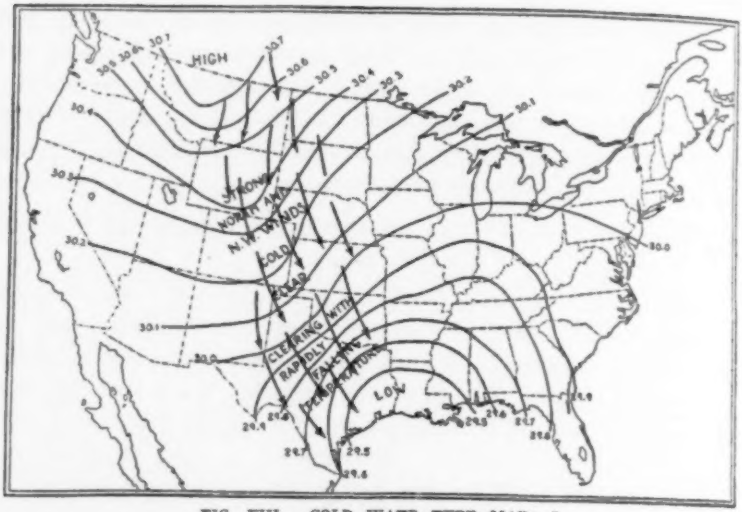

FIG. VIII. COLD WAVE TYPE MAP: I.

Figure VIII shows a pressure distribution favorable for the outpouring of a great volume of cold air from the high pressure area over western Canada, southward over the Great Plains and as far as the western Gulf region (Texas). Severe cold waves reaching far to the south, into the states bordering on the Gulf of Mexico, occur when a well-developed "cold wave high," accompanied by very low temperatures, thus appears in the northwest, and when there is, at the same time, an energetic cyclonic depression over the Gulf or southern Atlantic coast section. As the low (Fig. VIII) moves eastward, and then northeastward along or more or less parallel to the Atlantic coast, the cold wave sweeps eastward with the advance of the northwest winds, crossing the Mississippi Valley, overspreading the southern states and reaching the Atlantic coast. The high, with its low temperatures, normally moves southeastward across the plains, gradually decreasing in energy, and with lessening cold as it later swings eastward across the Mississippi Valley to the central or southern Atlantic coast. Many variations may occur in these suggested conditions. If there is no well-defined depression in the south, the high is less likely to move in a southerly direction, and the area covered by the cold wave will be smaller and will not advance into such low latitudes. If the high is less emphatic, or its cold less severe, or if the gradients are less steep, the cold wave will be correspondingly modified.

The situation broadly generalized in Figure IX is clearly not favorable for the transportation of severe cold into the southern states. In this case the cyclonic depression moves eastward along the "northern track," *i. e.*, across the Great Lakes and down the

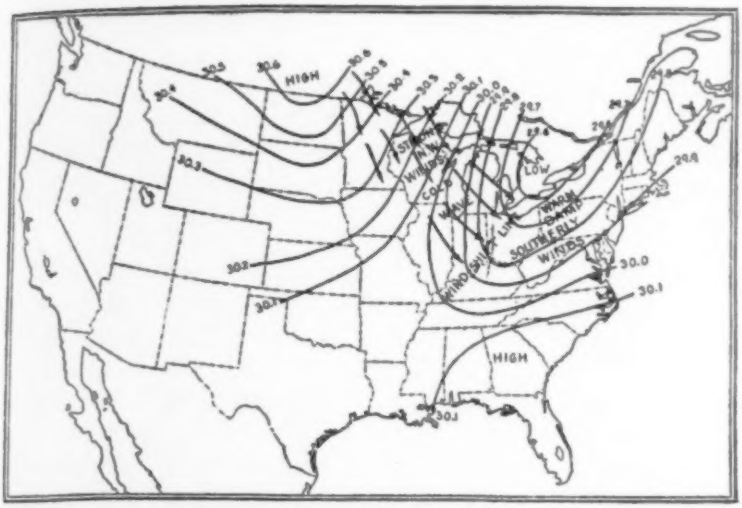

FIG. IX. COLD WAVE TYPE MAP: II.

St. Lawrence Valley, followed by a cold-wave high which follows more or less the same course. The cold wave under these conditions is limited to the northern and central sections of the eastern United States. Many variations of this general type occur. For example, the high may move southward from Canada over the lakes, with a low in the northeast. Under these conditions the northeastern sections, including New England and the middle Atlantic states, are alone affected. In this portion of the country, the cold wave is often preceded by an easterly snowstorm. Again, the smaller and the weaker the depression, and the farther north it is, the less severe and the less far-reaching is the cold wave. Certain large seasonal characteristics are controlled by the characteristics, the paths and the numbers of cyclones and anticyclones. Thus, when in a given winter more cyclonic depressions follow a southern route, being followed by well-developed cold wave highs coming from the northwest, there is a preponderance of cold northerly winds and the winter is likely to be unusually cold. On the other hand, when more depressions follow the northern track, especially if the highs also come from farther south instead of out of the Canadian northwest, there is a preponderance of warm southerly winds over the eastern United States and the winter is likely to be milder than usual.

A weather map which is more or less of a combination of the types illustrated in Figures VIII and IX is shown in Figure X. Here a trough of low pressure extends from the Great Lakes southwest across the Mississippi Valley to the western Gulf. When the gradients are steep, with a well-marked high in the far northwest,

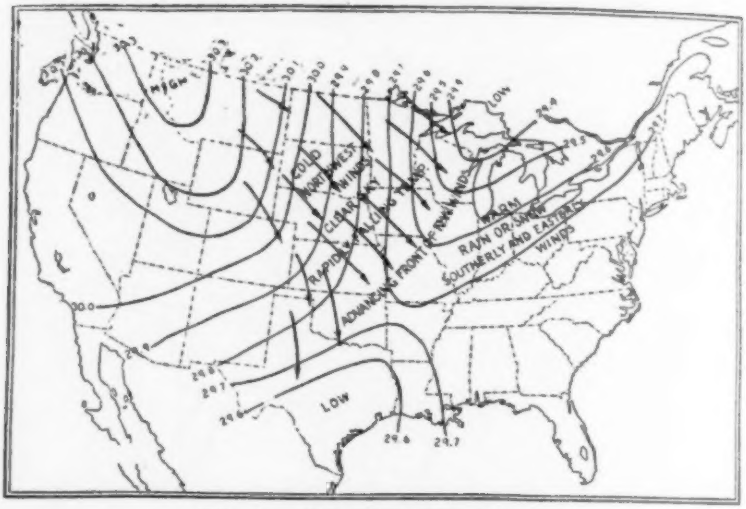

FIG. X. COLD WAVE TYPE MAP: III.

a severe cold wave sweeps the eastern slope of the Rocky Mountains and follows the eastward movement of the low pressure system across the eastern United States.

As has been stated above, these three generalized type maps are not to be taken literally, nor do they in any way show the great variety of conditions under which cold waves occur, and with which the forecaster has to deal. They are merely suggestions. But they may serve to make the matter clearer than would the description alone.

Tempering Effect of the Great Lakes[9]

The open waters of the Great Lakes have a distinctly tempering influence on the bitterly cold winds of a cold wave. This effect extends well on into the spring, when the moderating influence is of considerable economic importance in the fruit districts of the Lower Peninsula of Michigan and in other sections to leeward of the lakes. In a severe cold wave, Kingston and Toronto, on the north shore of Lake Ontario, may have temperatures from 10° to 20° lower than those at Oswego and Rochester, New York, on the opposite shore. This is by no means an infrequent occurrence. Grand Haven, Michigan, on the lee shore of Lake Michigan, similarly often is as much as 20° warmer than Milwau-

[9] See, *e.g.*, E. T. Turner: "The climate of the state of New York," *Fifth Ann. Rept. Met. Bureau and Weather Service of the State of New York for 1893*, 8 vo., Albany, N. Y., 1894, p. 370; *Meteorological Chart of the Great Lakes, September, 1913* (United States Weather Bureau); Mark Jefferson, "The Great Lakes in a cold wave," *Journ. Geog.*, Vol. 12, 1914, pp. 221-223; H. J. Cox, *loc. cit.*, A. J. Henry, *loc cit.*, and elsewhere.

kee, Wisconsin, just opposite, on the west shore. The whole Lower Peninsula is to a certain degree affected, but this influence naturally decreases rapidly on going inland from Lake Michigan. The lee shores of Lakes Huron and Erie show similar effects. The number of cold waves is furthermore distinctly smaller at stations on the lakes than at neighboring interior stations.

Cold Waves of the Western United States

Reference has thus far been made only to the cold waves which sweep across that portion of the United States lying east of the Rocky Mountains. The cold wave chart (Fig. I) shows that the rest of the country, lying to the west of the mountains, is also reached by sudden marked falls of temperature which meet the definition of cold waves. It will be observed that most of the Plateau area between the Rocky Mountains on the east and the Sierra Nevada-Cascade ranges on the west, has cold waves of the same degree of intensity as those of the same latitudes to the east. On the north Pacific coast, on the other hand, cold wave conditions resemble those of latitudes 10° or so farther south on the eastern side of the Rocky Mountains, while California and southern Arizona have cold waves of the same degree as those of the Gulf and southernmost Atlantic coasts.

The great mass of the Rocky Mountains is an effective barrier to the westward flow of the cold air which is carried southward and eastward from the northern Great Plains. Low minimum temperatures occasionally occur over the Plateau under anticyclonic conditions which have drifted eastward from the Pacific coast, the cold air being drawn southward by northerly winds blowing towards a marked cyclonic disturbance. Real cold waves are, however, not common. These are best developed when the high from the Pacific coast is intensified by high pressure over British Columbia.

The Pacific coast not only has a double mountain barrier on the east, against the cold of the interior, but is blown over most of the time by mild winds from the Pacific. Hence its cold waves are few in number, and not severe. They are associated with northerly and northeasterly winds, blowing out of a high over the northern Plateau, or moving southward over the Pacific slope, with a low pressure system preceding it to the southward. Between the two, steep barometric gradients produce a flow of cold air which advances from north to south, down the coast. The occasional frosts of California, which may be of serious consequence to the fruit industry, are the product of local radiation on clear, quiet anticyclonic nights.

American Cold Waves Compared with Those in Other Countries

Cool equatorward-blowing winds on the rear of extra-tropical cyclones are normal, but the peculiar winter conditions in North America, already referred to, combine to give these winds an unusual frequency and also an unusual intensity of cold. A brief comparison of these American cold waves with similar phenomena in other parts of the world is therefore instructive. This matter has been clearly summarized by Professor W. M. Davis as follows:[10] "The winter cold wave of Europe is much less pronounced than with us, and comes from the northeast instead of from the northwest. . . . If a cyclonic center passes far enough south to draw the cold air after it from the low plateau of central France, the wind is called the *mistral* as it flows down the valley of the Rhone to the Mediterranean. . . . Central Europe never feels the excessive cold that is produced by the cold waves of the upper Mississippi Valley. . . . The name cold wave is not employed there, although it is perfectly applicable. Farther east, in Russia and Siberia, where the continental extension allows a more severe winter, the colder cyclonic wind is more like our cold wave; when blowing violently and raising a cloud of fine dry snow, it is called a *buran* or *purga,* corresponding to the *blizzard.* . . . The southern hemisphere has cool waves from the south in the rear of its cyclonic storms; but in the absence of large land areas in high latitudes, the fall of temperature is never as violent as with us; no strong cold waves occur there. The wind of this kind in the Argentine Republic is called a *pampero.* The *southerly burster* of New Zealand also seems to belong here."

It is, therefore, not the nature of the phenomenon but its extraordinary development which gives the winter cold wave of the eastern United States its distinctive character.

The Texas "Norther"

In Texas, and over the region of the Gulf of Mexico in general, the cold (or cool) wave is called a "norther." This wind has all the characteristics of the squall or wind-shift line conditions. It usually follows a general warm, cloudy or rainy spell, comes as a rushing blast from the northwest or north; brings a sudden drop of temperature of maybe 25° or more in an hour, and over 50° or more in two or three hours in winter. Almost incredible stories are told of these temperature changes. Professor Joseph Henry noted that "on one occasion recorded the temperature fell

10 William M. Davis: "Elementary Meteorology," 8 vo., Boston, 1894, pp. 236-237.

in the course of three hours from 75°F. to a degree sufficient to produce ice an inch thick."[11] The wild sweep of the norther over the open plains is dreaded by all who are outdoors exposed to its chilling fury. Shelter is sought, when possible. Indoors, huge fires are quickly lighted; windows are closed, and the passing of the tempest is impatiently awaited. The sudden fall in temperature is especially disagreeable to human beings, and injurious to stock and to crops, because of the warmth and mugginess which precedes it.

Northers are classed as "wet" and "dry." In the former, the fall in temperature begins before the rain has stopped, and cold rain, perhaps turning into sleet and snow, follows. In the latter, the change to the cold clearing wind comes after the rain area has passed eastward. A wet norther is likely to freeze the rain on vegetation, covering fruits and flowers with an icy coating and causing serious injury. Stock left outdoors also suffers severely. Dark squall clouds rolling up from the north across the sky characteristically precede the norther. "The first appearance of the tempest," wrote Henry, "is a cloud in the north, which approaches the observer sometimes with great and at other times with less velocity, and frequently passes over his head in a series of arches composed of dense clouds separated by lighter portions."[12]

Texas northers occur on steep barometric gradients produced by a well-marked anticyclone advancing over the Great Plains towards the Gulf of Mexico following a low-latitude cyclonic disturbance moving northeastward, with the wind-shift or squall-line characteristics strongly developed. Cold waves and northers are therefore simply, as Ferrel clearly stated, the usual trough phenomena of cyclones, where these are well marked. Or, as Blodget pointed out some decades earlier, in describing northers, they "are but the clear weather side of a revolving gale, like the northwester of the coast of the United States."[13] The prevailing winter pressure distribution over the great central region of North America is itself favorable to the prevalence of northerly and northwesterly winds. The dominant condition is one of north-south gradients from the cold northern interior to the warm Gulf of Mexico. When this condition is intensified by the presence of an especially marked cold wave anticyclone over the northern plains, or a cyclonic storm originating over, or crossing, the western Gulf region,

[11] Joseph Henry: *Ann. Rept. Smithson. Instn. for 1871*, Washington, D. C., 1873, p. 452.

[12] Joseph Henry: *loc. cit.*

[13] Lorin Blodget: *loc. cit.*, p. 30.

or both combined, "the north winds may come down from the plains with great velocity, with a sharply defined head of cloud like a battering ram, replacing warm and stagnant air and causing a sharp and great fall of temperature. These are the well-known Texas 'northers.' "[14] These are, thus, simply temporarily exaggerated cases of the prevailing winter winds, similar, in many ways, to the *mistral* of Europe. The norther of Texas is therefore merely the local designation of cold wave phenomena already familiar through the preceding discussion but, owing to its occurrence in lower latitudes, it is accompanied by less extreme cold. Severely destructive northers are infrequent. Sometimes they advance far southward along the eastern shores of the Gulf of Mexico, and occasionally crossing the Isthmus of Tehuantepec blow onto the Pacific Ocean.

Well-marked northers usually do not last longer than a day or so. The wind then decreases in velocity, shifts to some southerly point, and a spell of fine and warm weather sets in—a transition as sudden, to quote an early writer, as that from "Labrador to Nicaragua." Overcoats and extra coverings are thrown aside; fires are allowed to go out; the winter is forgotten.

Pressure conditions favorable to northers are not limited exclusively to winter, although they are most marked and most frequent then. The norther of spring and fall, coming at a time of prevailingly higher temperatures, is disagreeably chilly. In the summer, on the other hand, the northerly wind is welcomed because of its relatively low temperature. It furnishes pleasant relief from the oppressive heat.

The Blizzard

"The sun at rising was hid behind a red mantel of clouds. The air was unusually moist. A gentle mist deposited moisture on every twig; the mist turned to rain; the rain to snow. About four inches of snow fell. The thermometer was in the vicinity of the freezing-point. About 9 P. M. the wind shifted to the northwest and its velocity increased to about forty miles an hour. It turned cold, and each separate flake of snow became a particle of ice. . . . As the wind would lift fine dust and whirl it through the air, so this body of snow was lifted. To distinguish the form of a human being ten feet away was impossible. A barn, even, could not have been seen twenty feet in front of one. It was a mad, rushing combination of wind and snow which neither man nor beast could face. The snow found its way through every crack and crevice.

[14] Mark W. Harrington, "The Texas monsoons," *Amer. Met. Journ.*, Vol. 11, 1894-95, pp. 41-54.

Barns and stacks were literally covered by the drifting snow, and, when the storm was over, cattle fed from the tops of the stacks. My sheep huddled together in the sheds and many of them were smothered. Persons lost upon the prairies were almost certain to meet with death, unless familiar with the nature of these storms. . . . I learned of many instances where persons were lost in trying to go from the house to the barn, and of other instances where cords were fastened to the house so that, if the barn should be missed, by holding onto the cord the house could be found again. During the blizzard the thermometer ranged from twenty above to ten below. After the storm it reached twenty-five below."[15]

Such, in December, 1865, was a blizzard on the plains of North Dakota, and such is a blizzard in that same region to-day: a sharp, biting, irresistible cold wave gale, with rapidly falling temperature, fine, dry, driven snow and cutting needle-like ice crystals. Its real home is on the northern Great Plains, but it also occurs, with diminishing severity and with lessened frequency, as one passes to greater distances from its northern habitat. In its typical development it is very destructive to cattle exposed to the full fury of its blast in the open plains, and many a farmer and cattle-man has been lost in its blinding snow-squalls and its bitter cold. All sense of direction is easily lost; and in the roaring of the gale the sound of the human voice is indistinguishable. "Caught in such a blast one runs the risk of suffocation, the action of the lungs being stopped by the swiftness as well as the intense cold of the wind, while the ice-dust, which penetrates the thickest clothing, is more choking than a summer dust-storm." The blizzard of January 12, 1888, in the Dakotas and neighboring states, came so suddenly after a spell of mild weather that between two and three hundred persons were reported to have lost their lives, being unable to find their way to shelter, and thousands of cattle perished.[16] Winds of over 50 miles an hour were recorded, with temperatures of —20°. The thermometer fell 50° in less than five hours at Helena, Montana, and at Crete, Nebraska, it fell 10° in five minutes.

The blizzard, like the cold wave, is a typical and distinctive American winter phenomenon: an occasional but fortunately not a frequent visitor to the sections where it has its home. Its most favorable opportunity occurs after a snowstorm, when the snow is still loose and soft, and on the steep gradients in the rear of the

[15] C. A. Lounsberry, reprinted from the *Northwest Magazine* in *Amer. Met. Journ.*, Vol. 3, 1886-1887, pp. 112-115.

[16] *Month. Wea. Rev.*, Vol. 25, 1897, p. 15.

retreating low.[17] As in the typical cold wave, the greatest degree of cold (it may be —30°, —40° or even lower) is not recorded until the gale has "blown itself out" under the clear skies and light winds or calms of the succeeding anticyclone. Yet the feeling of cold is far more intense during the gale.

There has been a good deal of discussion as to the origin and the first use of the word *blizzard*.[18] Professor C. F. Talman, of the United States Weather Bureau, has given some attention to this matter. The origin of the word has been plausibly traced to the German *blitzartig* ("lightning-like"), and *blizzard* may first have been used by early German settlers on the northern plains. At any rate, the term *blizzard* does not seem to have been used in a meteorological sense before about 1860. As is the case with any scientific term which has a definite meaning, blizzard should not be used indiscriminately to describe any particularly heavy snowstorm accompanied by high winds. Such a "popular" use of the word is quite general in the eastern United States, and is unfortunate.[19] True blizzards are of very rare occurrence in the latter region.

A memorable storm of this character occurred on March 11-14, 1888, which interrupted for several days telegraphic communication in southern New York, eastern Pennsylvania, New Jersey and southern New England. Snow-drifts of 40 feet in depth were measured in places. The wind velocities averaged 20-25 miles an hour for four days, and at times reached 50-70 miles. Boston, Massachusetts, was so completely isolated that for a day or two communication with New York and other cities was by means of cable via England. The economic loss, on land and sea, ran up into many millions of dollars, and numbers of persons suffered severely from the intense cold, the icy gales and the drifting snow.[20]

17 F. J. Bavendick, "Blizzards and chinooks of the North Dakota plains," *Month. Wea. Rev.*, Vol. 48, 1920, pp. 82-83.

18 See, *e.g.*, C. F. Talman, "Origin of the word 'blizzard'," *Month. Wea. Rev.*, Vol. 42, 1914, p. 692. See also Vol. 26, 1898, p. 562, and Vol. 48, 1920, p. 82.

19 See also *Nature*, Vol. 97, 1916, pp. 261, 280, 301, and Sir Douglas Mawson, "The Home of the Blizzard," London, 1915.

20 Everett Hayden, "The great storm off the Atlantic Coast of the United States, March 11-14, 1888," *Nautical Monographs No. 5, United States Hydrographic Office*, Washington, D. C., 1888; Winslow Upton, "The storm of March 11-14, 1888," *Amer. Met. Journ.*, Vol. 5, 1888-1889, pp. 19-37; A. W. Greely, "American Weather," pp. 225-226.

IS POLIOMYELITIS AN INSECT-BORNE DISEASE?[1]

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THE title of this communication was purposely put in the form of a query, primarily because I am fully aware that many of my hearers do not yet share the view that the spread of poliomyelitis is in any way related to the activities of insects and secondarily because I wish to make it clear at the outset that I shall attempt to present the evidence in a spirit of absolute scientific frankness. Such an attitude seems particularly necessary in view of several rather dogmatic statements which have been promulgated, criticizing the efforts of the medical profession and disparaging the attempts of the health authorities to control epidemics of this disease. I shall, therefore, carefully avoid anything which might lead you to prophesy that the approach of old age may find me hopelessly drifting toward a berth in the Anti-vivisection Society, the League for Medical Freedom, or some equally harmless and constructive cult of "Antis."

A hasty glance at the chart which I have prepared (Fig. 1) will call to mind the several possibilities which we must bear in mind while examining the evidence. The indicated categorical arrangement has been selected simply to facilitate the elimination of methods which do not accord with the observed facts.

Such a classification includes every method so far recognized by means of which infectious diseases are spread, and unless we elect to embrace the doctrines of Christian Science it seems difficult to conceive of any other method. These three groups are not entirely independent, for some diseases like typhoid fever, plague, anthrax, etc., may be acquired by more than one method. Nearly, or perhaps all, of these possibilities have been considered, more or less seriously, by persons who have dealt with either the epidemiological, clinical or experimental aspects of poliomyelitis, and consequently none of them should be summarily dismissed without

[1] Read before Section N (Medical Sciences), American Association for the Advancement of Science, Boston, December 29, 1922.

Conceivable Methods by which Poliomyelitis might be Acquired

1. Through personal contact with an infected person.

Portal of entry: mouth, nose, skin, alimentary or respiratory tract.

1a. Through contact with objects contaminated by microbes derived from a human case.

Same portals of entry, including ingestion with food or water, and inhalation with dust particles.

2. Through contact with infected animals, other than man.

2a. Through contact with objects contaminated by microbes derived from an animal case.

3. Through transmission by insects or other secondary animals, of microbes derived either from man, from other animals, or from contaminated objects.

FIG. 1. CONCEIVABLE METHODS BY WHICH POLIOMYELITIS MIGHT BE ACQUIRED.

some good reason. With equal assurance it may be stated that so far none of the methods mentioned has been actually proven, to the satisfaction of all those competent to judge, regularly to prevail. However, as has been already intimated, I am firmly convinced that the method dependent upon an animal reservoir and transmitting insect is the only one which brings into accord the quite extensive knowledge which we now possess concerning this disease.

It seems possible to handle the material more adequately in a few minutes by stating first the conclusions, so for the sake of brevity we will dispense with any dramatic dénouement at the end of the argument. The animal reservoir to which the finger of suspicion points is the rat, and the insect intermediary, the flea—exactly the combination which we know to be responsible for the perpetuation of bubonic plague. The first person to link the rat with poliomyelitis was Dr. Mark W. Richardson, who had become thoroughly familiar with the epidemiology of the disease during its epidemic prevalence in Massachusetts. His first public statement was made in 1916 and a more fully elaborated second publication appeared two years later.[2] My own investigations were begun in Massachusetts in 1911 and have been continued intermit-

[2] Richardson, M. W., '16, "The rat and infantile paralysis: a theory," *Boston Med. and Surg. Journ.*, Vol. 175, pp. 397-400; '18, "The rat and infantile paralysis: a theory," *American Journ. Pub. Health*, Vol. 8, pp. 564-579, 12 charts.

tently since that time, most extensively during the epidemic of 1916 in New York City. Much of the material to be presented is derived from these studies, some of which have already been published,[3] although a great deal has been obtained from other published sources, more particularly those of the Public Health Service, the Massachusetts State Department of Health and the Department of Health of New York City.

I shall attempt to discuss *seriatim* the several most striking peculiarities of poliomyelitis, dwelling more particularly on those which offer reasonable evidence concerning the probable method by which the disease is spread.

Sporadic cases of poliomyelitis have been known to occur more or less regularly in various parts of Europe and North America for many years and they still occur. They appear to arise *de novo*, and were at one time thought to show that the disease was not infectious. Now that its infectious nature is beyond doubt, they are still difficult to interpret and immediately suggest the presence of some non-human reservoir, since rabies, plague and certain parasitic worms have the same disconcerting habit of appearing from whence we could not surmise had we not discovered their animal hosts.

Poliomyelitis was first noticed as an epidemic disease in the last decade of the past century, and it is only since 1905 that any really extensive outbreaks have occurred, first in Europe, especially in the Scandinavian peninsula and almost immediately afterward in North America, as well as in several widely separated parts of the world. Its epidemic prevalence has been strikingly intermittent, with a tendency to exacerbation every second or, more noticeably, every seventh year. If this frequency be repeated, we may soon experience another outbreak in the United States, possibly during 1923, and if such should come to pass, it would seem very probable that a world-wide epidemic wave of poliomyelitis may be under way, similar to the present tropicodemic of plague which began at about the same time. If, on the other hand, the disease remains quiescent for several years longer, we shall have good reason to suppose that no such wave is in progress.

Practically all epidemics of poliomyelitis occur during the summer, and if we examine the seasonal prevalence of the disease we find that it regularly follows a curve closely similar to the one shown in Fig. 2, rising from a minimum in the early spring to a maximum during late summer. Outbreaks involving more restricted

[3] Brues, C. T., '17, "Insects as carriers of infection of poliomyelitis," chapter V of monograph on the epidemic of poliomyelitis in New York City in 1916, pp. 136-163, 2 maps, 5 figs., New York City Dept. Health.

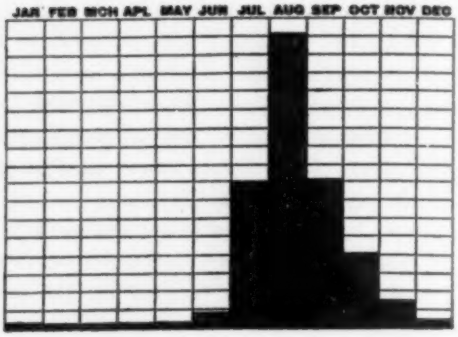

FIG. II. SEASONAL PREVALENCE OF POLIOMYELITIS IN THE UNITED STATES BY MONTHS, 1916. (After Brues, "Insects and human welfare").

areas show a still sharper peak (Fig. 3), but as the peaks succeed one another in time the composite curve rises and falls more gradually. A definite seasonal incidence such as this exactly reverses the equally definite winter prevalence of such diseases as measles, diphtheria and scarlet fever which we know to be acquired through personal contact. Thus, it will be seen from the accompanying chart (Fig. 4) that these diseases gradually begin to gain headway following the opening of schools and the beginning of various winter activities which keep all classes of population indoors and in closer personal contact. They reach their maximum in the

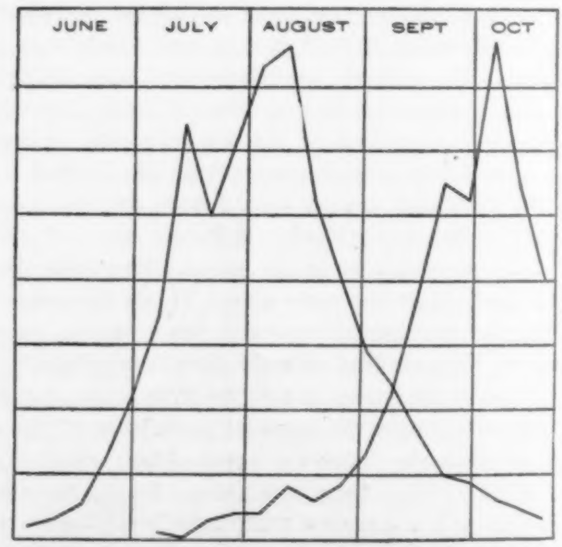

FIG. III. DEVELOPMENT OF TWO EPIDEMICS OF POLIOMYELITIS INVOLVING RESTRICTED AREAS, TO ILLUSTRATE RATE OF DEVELOPMENT AND SEASONAL RELATIONS. (ORIGINAL).

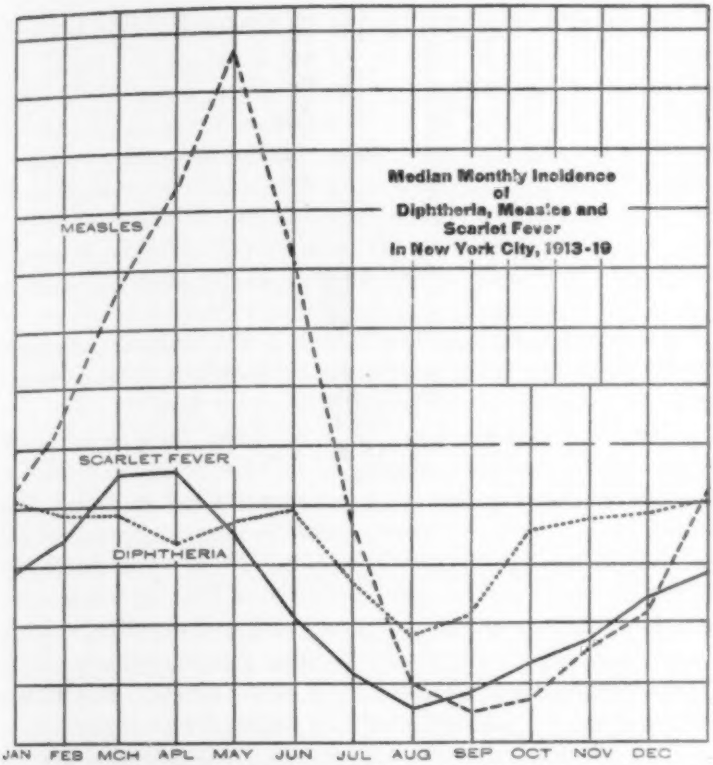

FIG. IV. SEASONAL PREVALENCE OF DIPHTHERIA, SCARLET FEVER AND MEASLES BY MONTHS IN NEW YORK CITY. (ORIGINAL).

spring when poliomyelitis is at its lowest ebb and then rapidly decline, to reach their minimum as poliomyelitis becomes most prevalent.

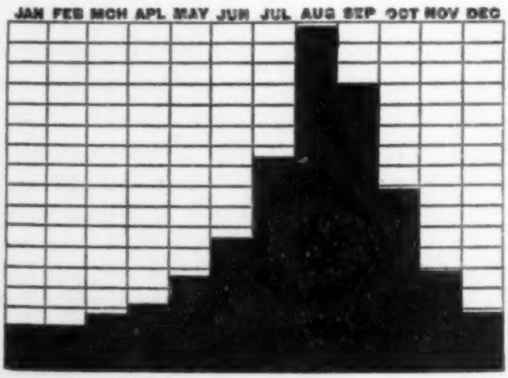

FIG. V. SEASONAL PREVALENCE OF MALARIA IN THE UNITED STATES BY MONTHS. (After Brues, "Insects and human welfare").

On the other hand the seasonal incidence of poliomyelitis coincides closely with that of the known insect-borne diseases, which become prevalent during the season when insect life flourishes. This means, of course, during the summer, except in the case of the louse-borne infections, for human lice find their winter conditions most salubrious. Thus malaria in temperate regions shows a summer and autumnal prevalence as indicated on the chart (Fig. 5). The variation is less than that seen in poliomyelitis, because malaria is most common in the southern states where the warm season is more prolonged.

Bubonic plague shows such a close similarity to poliomyelitis that I must mention it specifically, particularly because we know it to be a disease of rats spread to man by fleas.

The accompanying chart (Fig. 6) shows the seasonal development of two extensive outbreaks of bubonic plague in London and Leyden at the time this disease was prevalent in a cold climate similar to our own, compared with the recent epidemic of poliomyelitis in New York City. I need not dwell upon the similarity of the curves, except to note that the New York epidemic occurred earlier in the summer than is usual with poliomyelitis, and to say that the missing peak of the London plague outbreak, which I have indicated by a dotted line, is accounted for by a wholesale exodus from the panic-stricken city during late August.

The only other diseases that show a similar seasonal prevalence

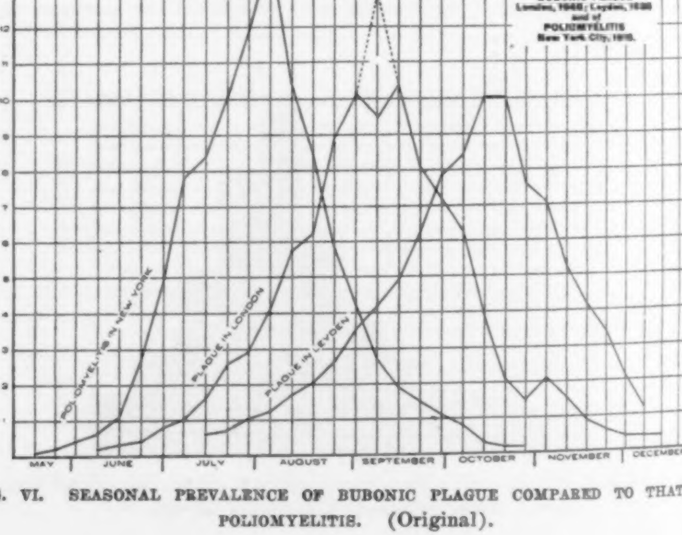

FIG. VI. SEASONAL PREVALENCE OF BUBONIC PLAGUE COMPARED TO THAT OF POLIOMYELITIS. (Original).

are enteric infections, such as typhoid fever and infantile diarrhea. Even here the influence of flies in contaminating food is an important factor and we find, as is shown on the accompanying chart, (Fig. 7) that the summer rise of typhoid fever is much more

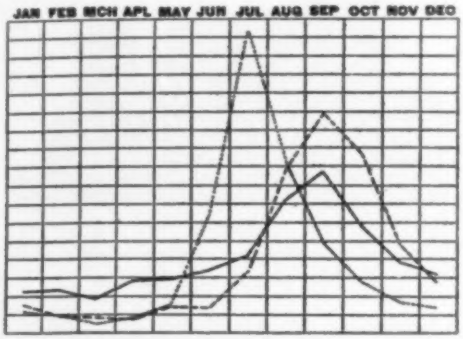

FIG. VII. SEASONAL PREVALENCE OF TYPHOID FEVER IN DIFFERENT PARTS OF THE UNITED STATES.
Dotted line, Alabama; dashed line, Washington; solid line, New York State. (After Brues, "Insects and human welfare").

marked where there is less adequate disposal of sewage. Thus, the season variation is less marked in New York State than in Alabama or Washington. Numerous careful studies have shown, however, that no relation can be established between the sources of food, milk or water and poliomyelitis.

It can be said, therefore, that the seasonal prevalence of the disease lends no support to the theory of contact contagion.

There is one fact relating to seasonal distribution which we must not overlook, as it has been urged as evidence that the disease can not be insect-borne. This relates to occasional winter outbreaks, at a time when most insects are not active. Statistics for 39 such outbreaks are available[4] and we find as I have indicated on the chart (Fig. 8) that they extend through the winter, although more numerous during the early winter months. All are included, although slightly more than half were outbreaks of less than ten cases each, some of these in large cities. Most insects are, of course, practically absent or dormant at such times, but fleas are not, as has been shown by observation, for example in Boston, where one of my former students, Mr. Lyon, found the prevalence of the cat-flea to vary greatly during the course of the year, approaching a maximum in midsummer, declining through

[4] Leake, J. P.; Bolton, Joseph, and Smith, H. F., '19, "Winter outbreak of poliomyelitis in Elkins, West Virginia," 1916-1917 Public Health *Reports*, Vol. 32, pp. 1995-2015, 5 figs.

FIG. VIII. THIRTY-NINE WINTER EPIDEMICS (697 CASES) OF POLIOMYELITIS, showing approximate number in progress during each quarter-monthly period. (Original).

the winter to a minimum during March and closely following the curve of poliomyelitis. We also know, of course, that bubonic plague has occasionally been epidemic in winter in cold climates, although this disease usually assumes the directly contagious pneumonic type during the winter season. I wish I had more time to show you that several other characteristics of winter epidemics of poliomyelitis accord with these conclusions.

Summer epidemics of poliomyelitis decline rapidly after the peak is reached, and if they have begun early in the season often disappear before cold weather appears, and before neighboring epidemics have subsided. This would naturally lead to the assumption that a severe outbreak immunizes the susceptible population through an enormous number of slight, unrecognizable or what we may most appropriately term "ambulatory" cases. This also explains nicely the failure of epidemics ordinarily to recur at the same place during successive years. Certain facts show, however, that this apparently plausible assumption can hardly be adequate. Thus we know that the disease always shows a most remarkable selection of children with reference to age. The chart (Fig. 9) shows this selectivity graphically, and we see that the most susceptible age is two years. If extensive immunization occurred, we should necessarily find a greater incidence among younger children in places where the disease was prevalent one or two summers previously. This does not occur, as the curves run so close together that the difference would not be significant, even if it were always in the expected direction, which it is not. We are, therefore, not justified in assuming wholesale immunization of the healthy population to account for the decline of outbreaks, unless we should add the biologically unwarranted corollary

of transitory or ephemeral immunity. Whether we have the immunization of some animal reservoir is, of course, hypothetical, but there must be some underlying factor apparently not human and not meteorological. The biennial increase of poliomyelitis in circumscribed localities is probably due to the same cause. On the accompanying chart (Fig. 10) this is shown as it occurred in Massachusetts from 1907-1910; while the foci in the western and eastern parts of the state were still clearly separated, the comparative prevalence shifted from one side of the state to the other in alternate years, a characteristic also noted elsewhere and apparently not explicable on the basis of a purely human disease.

The geographical and topographic relations of poliomyelitis present several features which are very characteristic and which, as we shall see in a moment, do not lend themselves to explanation on the basis of contact infection.

Rural communities are almost invariably more severely affected than urban ones. This has been observed everywhere that the disease has become epidemic. Even in New York City during 1916, the incidence of poliomyelitis in the several boroughs of that city was almost exactly in inverse proportion to the density of popula-

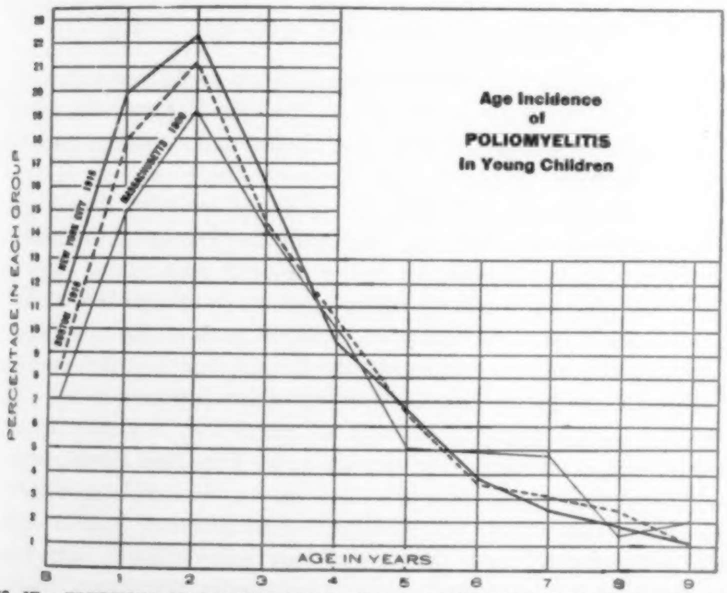

FIG. IX. INCIDENCE OF POLIOMYELITIS AMONG CHILDREN, WITH REFERENCE TO AGE, IN THE CASE OF THREE OUTBREAKS.

One (Massachusetts, 1909) was at the beginning of its epidemic prevalence, another (New York City, 1916) after the presence of the disease for some years in very small amounts, and the third in a locality (Boston, 1916) where the disease had been more or less epidemic for a number of years. (Original).

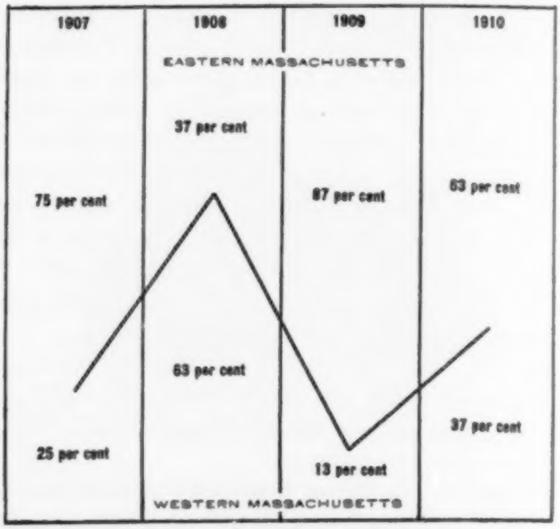

FIG. X. CURVE ILLUSTRATING THE BIENNIAL RISE AND FALL OF POLIOMYELITIS IMMEDIATELY FOLLOWING ITS APPEARANCE IN EPIDEMIC FORM IN MASSACHUSETTS.

The percentages above indicate the proportion of cases in the eastern part of the state each year, and the percentages below show the proportion of cases developing in the western part of the state. (Original).

tion. It was highest in Queensboro and Richmond (Staten Island), less in Brooklyn and still far less on the thickly populated island of Manhattan, which includes one of the most densely crowded areas in the world.

It will be noted that while the epidemic severity, even in the parts of a large city, does not vary with the density of the human population, it does appear to follow the rat population. This is shown perhaps more clearly by another much smaller area. This is the lower East Side, the most crowded part of the city, where any disease spread by contact should become rampant, but its incidence rate was lower than that of any entire borough in the city. Also, we must note that this area is bounded on two sides by the water-front of the east river and on a third by 14th Street, which carries a large sewer. Along these sections the incidence was exactly twice that which prevailed in the sections not directly adjacent to the water-front. The conditions here, which I have been able only briefly to outline, directly contradict any theory of personal contact and suggest something associated with wharves, sewers and the water-front—namely, rats.

When we look still more minutely at the spatial distribution of cases in a city like New York we are confronted by another anomalous condition. On a spot-map, where each case is indicated

by a dot, we find that there is a very evident tendency for the cases to group themselves in city blocks, that is to say, in the quadrangles of contiguous buildings, each separated by streets. Under such unfortunate conditions the only playgrounds for children are the streets, and this results in the mingling of the occupants of adjoining houses and of those on opposite sides of the street, while there is far less contact between those living on opposite sides of the block. Nevertheless, poliomyelitis spreads around or through the block more commonly than it crosses the street. The bearing of this observation on contact is obvious, and we are led to look for some agent that travels by more unconventional routes.

When Johnny suddenly shows up with a nice case of measles, chickenpox or some other disease, we immediately begin to wonder where he "caught" it, and nine cases out of ten we can single out some unfortunate playmate who "gave" it to him. Such is not the case with poliomyelitis; it comes out of a clear sky, so to speak, although when epidemic there are usually cases not far away—somewhere in the neighborhood. In other words, it is impossible to establish the probability of direct contact with a previous case in more than a small proportion of cases. To use the words of one group of investigators (Lavinder, Freeman and Frost) who rather lean toward the idea of contact infection, "in individual cases contact, either direct or indirect, with a previous case of poliomyelitis could but rarely be established, and in many instances the possibility of such contact could be satisfactorily excluded." Careful investigation of the cases on Staten Island in 1916 by these authors who searched for every possible contact showed that 29.2 per cent. of all cases (paralytic, abortive and suspicious), gave evidence of direct or indirect contact (through a third healthy person), positive or probable with a previous case, either paralyzed, abortive or suspicious. Ordinarily the percentage is much less, from 3 to 8 per cent., and we must remember that in diseases like plague, yellow fever and malaria where contact has nothing to do with infection, it can nevertheless be demonstrated in many instances.

Similarly, secondary or additional cases in the same family do not occur so commonly as they do among the known contagious diseases. This is shown graphically in the chart (Fig. 11), where we see on the left-hand side that scarlet fever and diphtheria are much more apt to attack an additional member of the same family than is poliomyelitis. This statement might be dismissed with the reply that poliomyelitis is less contagious, but the right-hand half of the chart shows that such a simple explanation will not suffice,

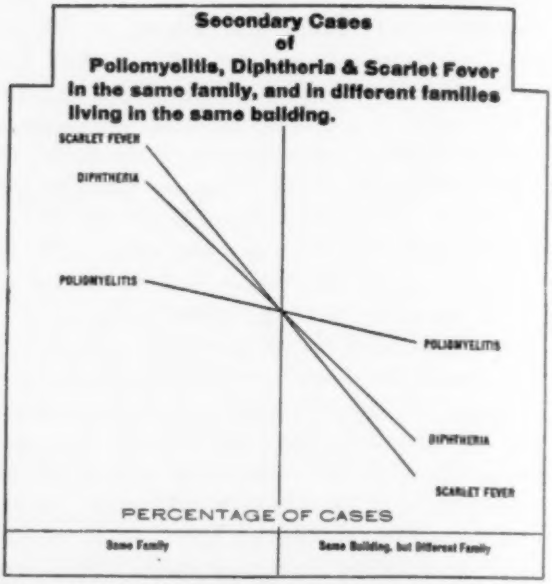

FIG. XI. THE DISTRIBUTION OF SECONDARY CASES OF POLIOMYELITIS, DIPHTHERIA AND SCARLET FEVER IN TENEMENT HOUSES IN NEW YORK CITY, 1916. Secondary cases of poliomyelitis develop much more commonly in another family occupying a part of the same building than do the other diseases. (Original).

for poliomyelitis is far more apt to spread to a different family in the same tenement than are the other diseases mentioned; that is to say, it tends to be distributed through a building with but little reference to the family unit. The very definite age selection of poliomyelitis undoubtedly influences this proportion somewhat, but there is plenty of susceptible material in such prolific groups and as is well known, diphtheria shows almost the same age selectivity as poliomyelitis. Thus we can hardly avoid the conclusion that the infective agent is not subject to the restrictions which limit human contact in tenements, but that it spreads through walls and floors just as it wanders through the larger city blocks.

The failure of the disease to spread in hospitals to nurses, attendants or other patients has been noted incessantly by various observers who have ordinarily attributed it to the precautionary technique of the modern hospital, which does not, however, entirely prevent the spread of the well-known contagious diseases.

The progress of epidemic spread of poliomyelitis has been carefully followed in a number of outbreaks in Sweden, in Massachusetts and in New York City and the adjoining states. It always moves with extreme deliberation and even in the great metropolis showed no tendency to acquire the speed mania which afflicts the

FIG. XII. MAP ILLUSTRATING THE RADIAL SPREAD OF THE EPIDEMIC OF POLIOMYELITIS IN NEW YORK CITY, 1916.

The epidemic had its origin at the center of the inner circle. (Redrawn from Lavinder, Freeman and Frost).

human population. The first cases occurred in Brooklyn near the head of the old Gowanus Canal, a tidal estuary extending from the water-front, best compared to the Chicago River in its palmy days. That its origin in this rat-infested area is a mere coincidence is, of course, quite likely. From the original focus, the epidemic spread generally into the surrounding parts of Brooklyn, and a number of more or less discrete secondary foci were established during the course of the following weeks. This spread was carefully studied by Lavinder, Freeman and Frost,[5] and their results, which may be best understood by reference to one of their charts (Fig. 12), are of extraordinary interest. Dividing the area into zones with the first group of cases at the center it became evident that the spread of the epidemic was markedly radial in character.

[5] Lavinder, C. H., Freeman, A. W., and Frost, W. H., '18, "Epidemiological studies of poliomyelitis in New York City and the northeastern United States during the year 1916," *Bull.* United States Public Health Service, No. 91, 274 pp., 46 maps, 21 charts, 51 tables.

Obtaining an average date of onset for all the cases in each zone and thus obtaining a "median" case, it appeared that these median cases succeeded one another in time, so that the crest of the epidemic passed from within outward at a slow but accelerating rate. Thus it required several weeks to attain the periphery of the five-mile zone, and thirty-five days to travel to the outer zone of the city. Coincident with this movement the prevalence of the disease declined in the district first affected, while it was increasing in the more recently affected zones.

Such radial spread is not comparable to the movements of the population of Brooklyn and is incompatible with their diurnal migrations into New York, for the spread of the disease westward was delayed by the East River and not hastened by the extensive movements of the people who cross the river. When the disease did appear in Manhattan, the simultaneous foci were widely separated.

Although the spread of the New York epidemic of poliomyelitis was not in accord with human movement, either in time or space, it coincides with the known migratory habits of rats. To forestall your conclusion that this statement is a figment of my own disordered imagination, allow me to quote a statement of the unprejudiced "Indian Plague Commission" concerning an epidemic of bubonic plague in Lucknow, an Indian city of over 200,000 inhabitants:

> When the commission started work in Lucknow in January, 1911, the city was infected by plague for the first time since 1907. The first cases were reported in the month of November from Hassanganj Ward, which, as has already been mentioned, includes several more or less scattered villages on the northern side of the river Gumti, which separates Hassanganj Ward from the rest of the town.
>
> Infection was confined to that side of the river till the month of January. In the latter end of that month, infection appeared more or less simultaneously in all the five remaining wards of the city. The epidemic reached its height in the month of April, after which it rapidly declined. . . . It will be noted that the epidemic did not reach its height simultaneously in all the wards of the city. Those earliest infected exhibited the highest plague death rate in the month of March, those later infected not till the month of April. The disease was actually declining in the two wards, Ganeshganj and Hassanganj, at the very time it was working up in the adjacent wards of the city.

I might mention a number of other matters, but the several points which have been so briefly outlined show the many difficulties and contradictions which make it extremely difficult and to my mind impossible to understand the epidemiology of poliomyelitis on the assumption that it is a disease spread by personal contact. These difficulties have been appreciated very generally by all those

who have studied the disease with the exception of laboratory workers, and to the work of these investigators I shall refer in a moment. The failure of the personal contact theory to meet the requirements has led to the assumption that poliomyelitis is spread mainly by healthy carriers, or third persons harboring the virus, who may distribute it in a more infectious condition than those actually in the prodromal or acute phases of the disease. This accounts for the fact that contact with a severe case involves little chance of infection, and explains to some extent, although very imperfectly, the spatial spread of epidemics. Many features, however, as we have seen, show it to be inadequate, and it appears to find little support by analogy with other diseases.

As is well known, poliomyelitis can be produced experimentally in monkeys, with virus derived from human cases. Portions of the spinal cord from human autopsies injected into the brain, peritoneum or general circulation or rubbed into the scarified nasal mucosa cause infection and by repetition the disease may be passed on indefinitely to other monkeys. In them it shows the typical paralyses and histological details seen in human cases.

Similarly, it has been found possible to cause the disease in monkeys by the intracerebral or intraneural injection of less active virus contained in the blood, nasal or oral secretions or dejecta of human cases and even from the secretions and dejecta of persons closely associated with acute cases. However, as with the similarly neurotropic virus of rabies, the virus of poliomyelitis, in whatever form, must be introduced within the tissues. Thus no portal of entry has been found in laboratory experiments which could function under natural conditions without some medium for inoculation, such as abrasions of the nasal mucosa or the bites of insects or other animals. As we have seen, the only supposition which is in accord with the epidemiological data would seem to be the one relating to insects and very particular insects at that. Many experiments performed with insects have been ill-conceived, since many kinds, such as lice, bedbugs and houseflies, on account of their seasonal distribution, method of migration, etc., could at most be only auxiliary factors. As you doubtless know, I was at one time led to believe, on the basis of less complete epidemiological knowledge, that the stable-fly fulfilled all the requirements. Other facts that have more recently come to light show certain discrepancies, and although transmission experiments with this insect have been successful when bodily parasites such as fleas and lice were not eliminated, several similar attempts have failed when fleas and lice were carefully excluded. We have shown, however, that poliomyelitis has none of the ear-marks of a louse-borne disease.

Several attempts to infect rats and other rodents, such as rabbits and guinea-pig, by present laboratory methods have yielded rather inconsistent and variable results. The clinical or histological picture of poliomyelitis is rarely or never present in a typical form in these animals, but rats show a high death rate following injection into the brain and peritoneum of cord or brain-emulsions from poliomyelitic monkeys. Passages through other rats are successful in the same way, but the transfer back to monkeys has not been accomplished.[6]

A further application of experimental data to the present discussion does not appear profitable, but I should like to point out some of the difficulties that beset the experimenter:

1. Experimental poliomyelitis has so far been produced only by the injection of virus through what are, in most cases at least, wholly unnatural channels.

2. The natural progress of the infection in spontaneous human cases may involve tissues such as the blood, which are omitted or bridged over in experimental work.

3. He can not know positively that the virus is a simple organism of uniform potentialities, rather than one of greater complexity represented only by certain stages in the material with which he deals.

I have wearied you already with too many details, some of which may seem irrelevant, but taken together they show that there is at least a strong probability that poliomyelitis is an insect-borne disease.

In closing I shall risk the chance of deeply offending the dignity of my audience by quoting a few passages concerning bubonic plague from an old edition of that much-maligned compendium of knowledge, the Encyclopedia Britannica, published in 1885. This article is extremely illuminating, not in the interpretation of the facts which it contains, but as an illustration of the impossibility of interpreting them before the exact nature of plague and the method of its transmission were suspected. These remarks also differ in lacking the finesse of modern medical verbiage, but if you will promise not to read between the lines and to visualize "healthy carriers" in place of clothing, the analogy to many of our present ideas concerning poliomyelitis will be apparent. The interpolated remarks on poliomyelitis from recent authoritative accounts are included for direct comparison.

[6] Stimson, A. M., '18, "Attempts to induce poliomyelitis in small laboratory animals," *Bull.* Hygienic Lab. U. S. Pub. Health Serv., No. 111, pp. 31-34.

> By whatever means, there is no doubt that plague is diffused or spread from one place to another, and that its spread is connected mediately or immediately, in most cases at least, with human intercourse, but this diffusion appears to take place as a rule slowly, and to be effected by the formation of new foci of contaminated atmosphere.
>
> The crest of the epidemic [of poliomyelitis] passed from within outward, requiring approximately 35 days to travel from the original focus to the outer zone of the city [10 to 15 miles away]. . . The simultaneous foci set up, for example, in Manhattan were widely separated.
>
> The plague of 1665 was widely spread over England, and was generally regarded as having been transmitted from London, as it appeared a month later than in the metropolis, and in many cases the importation by a particular person could be traced.
>
> New York in 1916 formed the original focus of an epidemic of poliomyelitis which ultimately extended and involved a wide area of territory. . . . In a significant proportion of the more isolated rural cases, where no definite contact could be established with a previous case, a history was obtained of association with known infected localities. . . .
>
> It is a very momentous question whether the contagion [of plague] is capable of being conveyed by clothes and other objects that have been in contact with the sick.
>
> Outside the human body, the living virus [of poliomyelitis] has been demonstrated in nature only in the dust of rooms occupied by the sick and presumably contaminated by their secretions; and possibly, though far less convincingly so, upon articles recently handled by the sick.
>
> It is generally agreed that plague is transmissible to another country only when it is epidemic and not from sporadic cases.
>
> The development in poliomyelitis of the power of epidemicity in all countries affected has been quite similar—first sporadic cases, then small groups, succeeded in time, as the disease gained force, by larger groups, until, as a rule, the disease has culminated in outbreaks of significant proportions.

The singular resemblance of these quoted passages illustrates incidentally several of the similarities between plague and poliomyelitis, but shows more specifically that our present explanation of the spread of poliomyelitis through contact partakes of the same vague uncertainty that pervades the older account of plague. It fails to explain several important and well-authenticated epidemiological characteristics of the disease, and we must regard it at best as a weak working hypothesis.

THE HISTORICAL BACKGROUND OF MODERN SCIENCE[1]

By Professor LYNN THORNDIKE
WESTERN RESERVE UNIVERSITY

The Need of Starting Right in the History of Science

THE history of science is practically a new field both for the scientist and the historian, and so, like a spotless sheet of white paper or an untrodden expanse of glistening snow, is a very tempting thing upon which to make marks or tracks, and I have to confess to being one of those who have been unable to resist this temptation. But it would obviously be advantageous if we could use this opportunity to open up a new field by opening it up in the right and best way, and not indulge in tentative activities of a kind which will only handicap and mislead those who follow us. The investigation of this new field should at least be up to date in availing itself of the latest achievements and most advanced methods both of historical scholarship and scientific research. Such a joint conference as this, then, where scientists and historians may take counsel together, seems a very fitting occasion for discussing what are the best methods of attack in dealing with the history of science. My acquaintance is limited for the most part to what may seem at first sight the remote historical background of the so-called middle ages and beyond; but inasmuch as only about one millionth part of the whole evolutionary process of this world and life therein has been added since the close of the middle ages—and when did they close, anyway?—perhaps I may bring to you from the study of that period, which is thus in reality very close and near to us, some warnings and suggestions.

The History of Science Should Be Studied Scientifically

Historians owe a great debt to the natural and exact sciences for the conception of a science of history. Although some historians maintain that such a science of history is impossible because we can not experiment with the past and because the extant

[1] An address delivered at the joint session of Section L, American Association for the Advancement of Science, with the History of Science group from the American Historical Association, Thursday, December 28, 1922, at Cambridge, Massachusetts.

remains are so fragmentary, and that therefore they are at liberty to reconstruct or imagine the past as they please, the majority of historical workers feel that these considerations only make doubly important the very thorough gathering and exceedingly careful and accurate measurement and interpretation of such materials as we do have. We feel the need as much as or even more than you of thorough scientific training, equipment and scepticism. We have to use the microscope of minutely sensitive critical insight, the balances of delicately suspended judgment and absolutely dispassionate appraisal. I say this because it has seemed to me that sometimes scientists, when they first enter the historical field, tend to kick up their heels, be exuberant in their new-found pasture, and follow the example of certain historians who run snorting around at large instead of yoking themselves to the heavy plough of scientific historical method and drawing a straight furrow. The history of science must be studied scientifically. One must no more follow authority than one would in the laboratory. One must accept only such scientifically demonstrated results as one would in a scientific paper after testing them further for oneself. As the laboratory equipment and method of the sciences are but a thing of yesterday, so great caution is required in using the history books of a previous generation. And in a subject so full of uncertainties and marked by relativity as is history, one must hesitate long before selecting this or that factor or personage for special emphasis.

Relation of the History of Science to the History of Civilization

Most of us will probably agree that history in the narrow sense, as presented and covered in courses given hitherto by the departments of history in most of our institutions of learning, has little vital connection with the history of science which relates rather to the history of civilization. I will not stop to define this phrase, "history of civilization," as I think all of us here are in fundamental agreement as to what constitutes civilization. I find myself, for example, interested in almost exactly those same books on, and sides of, civilization other than science proper which Dr. Sarton includes for consideration in the pages of "Isis." It is true that books have been published recently with civilization in their titles which in substance are still mainly repetitions of the old political and military history. But the mere change in title is significant of a change in interest, and the main reason why these recent books do not make their contents conform better to their covers is that their authors did not possess the broad appreciation

or patient industry to collect the necessary new material for a true history of civilization. Indeed, any philosophy of the progress of civilization, adequately supported by detailed researches and acceptable in its general outline to common sense, is as yet as much in its infancy as is the history of science itself. And very naturally so; for how can the history of civilization be adequately comprehended when the history of science remains so largely unknown? The history of art has recently received the attention of many specialists and publications and made rapid forward strides; the histories of literature and philosophy made their debut still earlier; but even these departments of the history of civilization will be incomplete until the true relations of the science of the past to them is made more clear.

The Danger of Sweeping Generalizations

Indeed, almost all histories of art, literature and philosophy that I have read, however scholarly they may have been in their own special spheres, have shown a weakness not merely in regard to the scientific knowledge of the past but also in regard to the main current of history and civilization. Briefly, they have said and assumed too much, and, instead of sensing the relativity of history, have indulged in unwarranted generalizations. For instance, they speak with altogether too much confidence concerning "the spirit" of any age in question. Yet the spirit of any age would seem almost its most elusive feature; the most difficult to capture, define and measure; rightly to be estimated only after all the facts are in and have been carefully weighed and classified; and furthermore, unfortunately, the one point on which rhetorical and impressionistic but not overscrupulous historians or word-painters of the past have been most likely to give vent to unrestrained imagination. The ordinary reader accepts eagerly these easy generalizations and such brief catch-words to describe whole periods as Renaissance, Scholasticism, Medievalism, Reformation, Age of Reason, Modern Progress. But they are rather more misleading than convenient, and to the trained eye usually betray a lack of detailed acquaintance upon the part of their users. Certainly the fitness of such rough designations has never been scientifically demonstrated, and they must not be taken as axiomatic. On the contrary, most recent detailed research has tended to disprove them, except—and here comes the pity of it—in those numerous cases where it has unquestioningly based its further painstaking investigation of minor points upon this false foundation of sweeping generality. The very notion that history falls into periods violates the great law of historical continuity, as Professor James

Harvey Robinson was pointing out when I began graduate work in history twenty years ago; but while almost every one agrees to this now, almost every one also still continues—thereby admirably illustrating the law of historical continuity itself—to assume the periods as a basis of classification, argumentation and generalization, and I somewhat regret to note that even you scientists, despite your faith in gradual and unceasing evolution, keep presenting us with additional periods, Pre-Chellean, Mousterian, Aurignacian, Solutrean, Magdalenian and what not.

History of Civilization Has Not Yet Been Fully Investigated

Another reason why we do not yet have a complete notion of the course of civilization in general, against which we may set the history of science in particular, is that the early history of mankind and of the ancient civilization of the near east has only recently been brought to light, while China and India have scarcely been taken into account in our western efforts to trace the evolution of human civilization. Yet their long unbroken development, their voluminous literatures, assuredly furnish most illuminating illustration all along the line—parallel cases or contradictory cases as the case may be—and must be included before we shall have a satisfactory synthesis. It would, therefore, seem the part of discretion for the historian of science to refrain for the present from all sweeping generalizations concerning such matters as the spirit of an age or the character of civilization at large, and above all not to take such generalizations from antiquated authorities or from books that never were authoritative, but rather limit himself strictly to what scientists were doing and thinking in the past, and thus supply a true foundation for a later unprejudiced synthesis.

Inner Mental Development More Important Than Outward Circumstance

In any case has not the history of science through the ages depended more upon the development of the scientific mind than upon outward circumstances? Superstition and folklore, magical practice and belief, divination of the future, do not appear to have been forced upon man by outward circumstances but to be an inevitable stage in the development of the human mind, though of course they may come to be sanctioned and maintained by society. The same would seem true of science itself. On the other hand, war and cruelty, persecution or neglect of unusual individuals—persecution is preferable as an advertising medium to neglect—and intolerance in one form or another have been pretty much a constant quantity in all ages of human civilization thus far; and

when the historian dwells upon them inordinately in any one period, it is apt to be a case of hypocritical indication of a mote in another's eye when he might better be employed in removing a beam from his own. We, who invent poisonous and deadly gases to slaughter mankind wholesale, hold up our hands in horror at the more discriminating activities of the Holy Inquisition, which as a matter of fact very seldom persecuted any one for scientific views, but medieval church councils forbade the use of military engines against Christians as being too murderous and perhaps kept Greek fire out of western Europe, therein displaying a medieval prejudice against inhuman war inventions which two nineteenth century historians of artillery somewhat impatiently ascribe to "ignorance, religion and chivalry."

The Conflict of Science and Religion Has Been Too Much Dwelt Upon

It would indeed be well if historians of science from now on could forget a little—if Mr. Bryan and Kentucky legislators will let them forget—the concept of a conflict between science and religion. I do not mean to say that there has not been a conflict and that it is not still irritating, but it does seem to me that it has been overemphasized and is not the *leit motiv* of the entire history of science or of the history of science since the beginning of Christianity. Pagan Antiquity persecuted its scientists more than the Middle Ages did theirs. And Mr. Bryan is not a relic of medievalism as this morning's paper says someone intimated at these conferences yesterday. Mr. Bryan is a distinctive product of our modern civilization. There are many other things that have conflicted and still conflict with science besides religion, and an unscientific attitude is displayed in plenty of other places than churches. One might, for example, wax eloquent over the conflict in our own time between science and advertising, the trashy popular reading, not literature, which goes with advertising, the popular education which trains the masses not in useful trades but in just enough book-learning so that they may read the daily paper and cheap magazine and may be taken in by advertising, and trains the few who go on to university courses in business psychology just a little more so that they can fool the others by advertising. If half this time and space and effort that is now given over to tempting and deceiving and stimulating and glutting the appetite of the consumer were devoted to training and encouraging the producer, what art we might be enjoying instead of constantly consuming more than we produce and robbing future generations of their natural resources. For twenty years now I have been

studying the magic of the past, and, believe me, some of the present generation of advertisers need yield nothing to the past generations of magicians in their trust in the power of mere words and images and agreeable mental illusions and delusions, in their theory of some occult virtue of salesmanship, and in their exploitation of popular lusts and credulity. The chief respect wherein they differ from the old magicians is that these advertisers have less regard for concrete objects and for laws of nature. It is indeed painful to see institutions of higher learning begin to pander to this popular immoral and unscientific demand from the business world. Still it need not give us a great deal of concern; let that sort of people teach advertising if they like; so long as they keep out of history and science, it is so much gain. Does this diatribe against modern advertising seem to your cool common sense and sane judgment a trifle overdrawn—perhaps even out of place in a scientific discussion? Very good! But let me add that it is not a whit more so than are most animadversions by historians of science upon the medieval church.

The Passing Popular Milieu Is to Be Disregarded

Moreover, I look back to the centuries before popular education was supported by printing, and in the second century I hear Galen complaining that there are not five persons known to him who really prefer truth to seeming; I hear Boethius in the sixth century grieving that the vulgar have torn off philosophy's robes and left the essential truth naked and crying for covering; I hear William of Conches in the twelfth century grumbling at the way that the bars have been let down in the educational system in his day, and even ceasing to teach because of the onslaught of the unskilled multitude; I hear Roger Bacon in the thirteenth century embittered by the facile successes of the boy theologians. But where to-day are those popular, superficial, successful contemporaries of whom Galen, William, Roger and other real scholars and scientists in the past complained? Gone! absolutely forgotten as individuals, very probably not a single manuscript written by them preserved, unmentioned in the writings which are extant except collectively and unfavorably; in short, but for the discontented grumbling of the Galens, the Williams and the Rogers we should have no evidence of their *quondam* existence. But Galen, William, Roger and their peers live on. In the passing world of talk rank weeds may flourish, but in the enduring world of books there is a survival of the fittest. The trouble with us historians has been that we waste our time in writing histories of politics for statesmen who never look into a history until they come to write their own memoirs, or economic

history for business men who read nothing but the stock market reports, instead of writing histories of books for readers. Historians of science need give even less attention to the fleeting ghost-like "spirits of the times" to existing society and contemporary custom, to political and economic conditions, while they may center attention the more on the enduring and progressive process of human thought. We can trace our intellectual ancestors a long way back. Each new war blots out the interest in the previous war; each change of ministry relegates once familiar figures to a gloomier obscurity; but every future scientist can find common ground of sympathy with those men of old. History, as Osler so well said, is simply "the biography of the human mind."

The Progress of Thought

The history of science, when sufficiently disclosed, should throw a great light on the problem how new ideas and theories gradually evolve out of the previous common stock possessed by mankind. In analyzing past writings and surveying past centuries I have been impressed by the slowness and gradualness with which ideas change, and by the really very small number of ideas which men have thus far entertained or expressed, much as man has domesticated only a few animals. Many men of learning, and famous ones, too, have seemed to repeat ideas parrot-like, and I can not convince myself that this is merely patristic or scholastic; it has seemed to me everlastingly human. There are also, it is true, minds that seem more restive, skeptical, experimental, original, creative; but when any new conception emerges, it often appears to be not the product of a single mind but rather to have been entertained simultaneously by several contemporaries. Thus, when the time is ripe, a new idea takes hold of the more progressive and open minds of that generation. And I wonder if we have sufficiently allowed for the wide and rapid spread of ideas in the past, despite linguistic barriers and primitive methods of communication. After all, the ancients represented fame and rumor as swift. If eels migrate incessantly from one region of the Atlantic to inland streams and ponds of Europe and America, if germs of disease carried the Black Death from Tartary to England, if Chinese jade went through to Troy four thousand years ago, would not winged words and valuable ideas spread, too? The ideas were fewer than the eels or the germs, it is true, but are they not also more indestructible? Ideas change, but it was a medieval writer who said, "Science always is making acquisitions and never grows less."

Importance of the Middle Ages

Already I have ever and anon been defending the so-called middle ages, and my next point will be that they constitute the immediate and most essential background of modern science. It will not do to trace the story of science through the classical period and then, in the words of a book on the Septuagint which I have just been reading, "resume . . . after a blank space of, roughly a thousand years with the invention of printing." No, we must abandon the absurd prejudices against and ignorance of the middle ages which we have inherited and poll-parroted from narrow Italian humanists, from Protestant reformers and Fox's Book of Martyrs, or from the eighteenth century deists, Voltaire and Tom Paine; we must correct and expand our notion of "modern progress," and subject the period before America was discovered to impartial open-minded scientific investigation. The historians of art have done this and found Gothic architecture first in quantity of noble remains and second to none in quality. The philologists have done this, discerning in the middle ages the cradle of our modern languages and literatures. Now, after having sought out, scrutinized scientifically and published most of the extant material in the vernacular languages, they are, I am glad to say, beginning to turn to the richer medieval literature in Latin and are organizing for its systematic exploitation. Students of economic history are pointing out such facts as that the same English towns which were prosperous and prominent in the thirteenth century came to life again only in the nineteenth century. Similarly representative government, found all over Europe in the thirteenth century, was thereafter gradually suppressed by kings until it revived again in the last century. In science and learning there has been no such setback as that, and no one must expect to find a startling likeness between the science of the thirteenth and the science of the nineteenth centuries, because other centuries of scientific progress have intervened between them. It is also true that in western Europe the very earliest medieval centuries seem a time of retardation in scientific development analogous to the depression which has prevailed in architecture and sculpture since, say, the seventeenth century. But the remainder of the medieval period has abundant extant materials for the history of science, more so probably than for any other side of human life except religion and perhaps art. The works can be more accurately dated and the relations between different authors traced more clearly than in the age of Greece and Rome. Various scholars have begun to publish and edit portions of this hitherto too neglected material, and the further study of it should greatly illuminate the process of human

thought in general and the development of modern science in particular. There is much magic and superstition intermingled with this medieval science—as, for that matter, there was with ancient science. This we must study, too, if we wish at all completely to comprehend the evolution of human thought and of modern science.

Evolution and the History of Science

You scientists, who accept the theory of evolution, who not merely experiment in the present but study fossils and the bones of extinct animals, who trace geological formation far, far beyond the first vestiges of human history and thought or even life, who perhaps experiment with the most primitive and elementary forms of life in order to understand the highest forms, who have abandoned the belief in permanence of species, who have tracked the sources of the most complex organisms back to the simple single cell and find there, perhaps, determinants of all the long-drawn-out later developments—you scientists, I say, can surely comprehend not the mere value but the pressing necessity for tracing the history and evolution of science itself, and for tracing it far, far back of the nineteenth century or Newton or Galileo or the invention of printing, for investigating it not merely in the recent butterfly stage of modern science, not merely in the larval stage of Greek thought, but also in the pupa of the so-called middle ages, and in the egg, it may be, of primitive folk-lore. You will not hesitate to commend the study of that other and seemingly earlier species of human thought, the superstitious and magical, with which science was for a long time at least closely related, if it did not indeed evolve from it. You will no more scorn the earliest crudest effort at experimentation, the first childish curiosity concerning nature, the first fantastic superstitious attempts to control nature than you would scorn embryology, the cell doctrine, and the investigation of planarians. It may not be such a far cry after all from such a treatise as the supposititious "Secrets of Women" of Albertus Magnus to recent theories of sex determination.

The Past Was Not Romantic and Unnatural

As you undertake to explain all past geological change by processes which can still be observed to-day, so you will expect to find the human mind developing slowly but steadily and scientific progress occurring step by step. But you will be suspicious of any historian who represents the past as romantic and unnatural; full, for instance, of inquisitors with thumbscrews, of imprisoned scientists writing in complicated ciphers, or of marvelously cultured Arabs, although their immediate ancestors were illiterate nomads and their present progeny are blind to the benefits of

British rule in Mesopotamia. What was the true state of affairs? Something nearer to this: even theologians obsessed by scientific curiosity, writing mathematical treatises, and performing natural experiments; even writers of the cryptic and occult recognizing the ascendancy of science; and far more scientific manuscripts in medieval Latin extant from little western Christian Europe than in Arabic from all the vast expanse of Moslem rule from Spain to India and Madagascar. When Pliny the Elder called his combined conspectus of ancient science and natural magic and record of civilization "Natural History," he chose a good title. May we investigate both nature and civilization as he did; and not only may our science be "organized common sense," but our history of science be scientific and natural and free from that credulous, fantastic, exaggerated and romantic strain, from which Pliny, try as he might, was unable to purge his book and his thought.

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THE OLD WORLD IN THE NEW

By Professor EUGENE VAN CLEEF

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THE production of food in New England is not adequate to the needs of the people. Nearly 80 per cent. of the food consumed is brought from points outside the region. This means a constant high living cost. If one urges the New Englanders to consider the possibility of producing more food they respond rather complacently to the effect that all of the desirable lands are now under cultivation, and hence no material increase in the local production is possible. Yet, while they say "it can't be done," a new Pilgrim arrives and points the way. It is the Finn, as resolute and zealous an immigrant as has ever come to America, who has solved the problem of the better cultivation of New England soils and consequent increase in food production. The native people of this northeastern corner of the United States, as well as those in many other parts of the country, have an opportunity not only to increase their food resources, but to increase the value of their lands and return profits to themselves, if they will but heed the Finn, who has demonstrated his efficiency and stands ready to serve further.

Although the Finn came to Boston as early as 1860, his presence has not attracted much attention, for his coming has never been in consignments, by boatloads, or in terms of "immigrant movables." Industrial agencies have had no hand in bringing Finns to America. The earliest Finns were sailors, impressed by the possibility of earning a living more easily in America than in the home land, where they suffered from the oppression of a Russian autocracy. To-day they determine their own destinies, for in 1917 Finland declared herself a republic and was first recognized as such by the United States.

These sailor pioneers met with success at once and wrote their friends or in some instances ventured back to Finland to tell their friends and relatives of the economic opportunity awaiting them across the seas. As the years rolled by the Finns came in greater numbers, although at no one time in large numbers. The migratory process has always gone on quietly. Not all the Finns landed at the port of Boston, some having reached New England by way

of New York City, and scattered throughout New England. The earliest immigrants found their way out of Boston first to Cape Ann, where they were given steady employment in the granite quarries. Later, the quarries of Quincy and Fitchburg attracted many, while the lumber industry in other parts of New England lured some. After a while the Finns turned to the textile mills, chair factories and other industries which offered immediate work and quick cash returns. The Finn pays his way from the outset and avoids the stigma of becoming a public charge; hence his readiness to adapt himself quickly, even though temporarily, to any sort of work which will enable him to support himself until such time as he can better his condition.

The Finn is thrifty and independent. Both of these qualities are the consequence of his life upon the farm in his native country where isolation and the struggle against the odds of nature challenge the strongest and bravest of men. He has consequently developed a penchant for work, a tenacity of purpose and a skill in farm management which may well be the envy of the peer of America's best farmers. His objective in America is not residence in the industrial center, where the permanence of home is not all too certain, but rather upon the land, where his future is entirely a factor of his own direction and where he may commune with nature. Furthermore, the New England environment reminds him of Finland. Its glacial lakes, its boulder-strewn surface, its numerous elongate hills, its woods of graceful white-barked birches or stately spired evergreens and the deep winter snows "are just like home." The urge, in this environment, to do what he did at home, but under a political régime offering him freedom of thought and action, is too strong to resist and at the first opportunity he turns to the land.

Managers of industrial plants loathe to see the Finns move landward. They commend them as among their best workers and not infrequently make part-time arrangements which permit them during the early development of their farms to spend a portion of their time in the factory. Such an arrangement is mutually advantageous, for while giving the employer the benefit of Finnish labor it enables the Finns to secure some ready cash so essential while waiting for the first crop to mature. The Finn's mechanical skill has evolved for much the same reason as did that of the Yankee farmer of fifty years ago. The isolated farmer can not call in a plumber, a carpenter, a blacksmith or other specialist, but must be Jack-of-all-trades. So it is, that when the Finn enters a factory without previous experience in the particular industry, "he learns quickly." He soon becomes expert. He thereby de-

velops a double value to the community, on the one hand as an efficient factory employee, oftentimes excelling all other nationalities, and on the other hand as a superior tiller of the soil.

The Finns of New England have centered principally in Gardner, Fitchburg, Worcester, Maynard, the suburbs of Boston, in Quincy and in the Cape Ann district. Smaller numbers live in Peabody, Norwood and the vicinity of Cape Cod. Altogether there are approximately 35,000, including native and foreign born, in the State of Massachusetts, with a scattering in Vermont, New Hampshire and Maine. Throughout this area there are many "rundown" farms. Some of them have not been under cultivation for the last five to fifteen years. Outside of New England such farms have been known as "abandoned," but the New Englander says there is no such farm in his part of the world. It perhaps is not worth while to split hairs with him on the difference between a run-down and an abandoned farm. The fact remains that these farms have been in a state of abandoned cultivation because the struggle has been too severe for the Yankee farmer or he has not been able to solve the problem of how to farm these particular pieces of land. Now enters the Finn, who boldly, slowly, methodically and laboriously begins to rehabilitate these farms and to succeed where his predecessors have failed. He purchases a cow, some chickens and a horse, if funds permit. The first two items give him a substantial food supply in the form of milk, butter, eggs and even chicken-meat occasionally, while the third offers power and transportation. He clears a few of the almost innumerable boulders, cuts off a portion of the dense second growth vegetation to make room for hay and enough of truck garden products for his own use, and drains a portion of the land. Tree stumps give him no particular concern at first, for he just cultivates around the stumps. In the course of time, and for the Finn time accomplishes much, all the land will be cleared, drained and under the plow.

The first year of farming passes, the second year rolls by, a third year eventually terminates and yet much remains to be done. Is the Finn discouraged? Not at all, for he has vision and patience; he is encouraged by what has already been accomplished and knows that constant labor for a few more years will bring the realization of his dreams. The end of the fifth year, the seventh year and even the tenth year mark his successive goals.

In the vicinity of Gardner and Fitchburg, where ten or fifteen years ago Finnish farmers were a rarity, to-day they supply a very considerable portion of the citizenry of Worcester county with vegetables, small fruits and milk. In the spring of 1922 nearly

100 Finnish farmers marketed not quite 100,000 quarts of strawberries. This is a record commanding the careful consideration of every native New Englander. It is a record established upon those run-down farms and also, in part, upon new lands which the farm bureaus of the state tell us are profitable only for the growth of pine. The Finn is applying the experiences of his home land plus certain remarkable qualities evolved through many generations of ancestors. He knows how to solve just such problems as the lands of Massachusetts present and is demonstrating without the peradventure of a doubt that what the New Englander says can not be done, agriculturally, can be done. The Finn is a new Pilgrim come to New England to play a new rôle. He is increasing land values, increasing the food supply, and establishing permanent homes where the best of citizenship develops. He is doing all this with essentially no encouragement from the great Commonwealth of Massachusetts and in the face of much discouragement.

A few people say the Finn is a radical and hence not desirable in America. They justify their attitude toward him upon these grounds. A sweeping indictment of this sort deserves investigation. Our lack of a scientific attitude of mind toward the immigrant problem is fraught with much danger. New England's unwholesome caste-system atmosphere serves but to stay the wheels of progress. Here is an opportunity for gain to New England and America, yet because of the absence of scientific methods which would lead us to a correct understanding of a people otherwise strange to us, we automatically encourage discontent and social unrest. What are the facts relative to the Finns?

About 40 per cent. of the Finns are Socialists and a fractional portion of one per cent. of this group is actually radical. Neither the Socialists nor radicals dominate Finnish life, although the latter cause all the trouble which has brought the whole people in some instances into unfair ill-repute. Clearly it is not right to judge the majority action by the behavior of an insignificant radical minority. It would be just as unfair to say that all Americans whose ancestors came over in the Mayflower are thieves just because a few now and then are caught stealing.

The Finn's radicalism is not all of his own making. Seemingly, only the I. W. W. organization has concerned itself seriously with the Finn and to the credit of the Finn, be it said, very few have joined its ranks. If we Americans would put forth an equal effort to interest the immigrant Finns in our institutions there is no question but that radicalism would be an unknown factor among them. The social worker needs to study the historical, political, geographical and anthropological background of the newcomer and approach

him accordingly instead of trying to teach all immigrants by the same formula.

The Finns have an oriental ancestry modified by a few hundred years' residence in Europe. Good evidence shows that they migrated from central Asia, the region of the Altai Mountains. One group upon reaching the Volga River moved up that greatest of Russian arteries and thence into northern Finland. Another group crossed the lower Volga, proceeded across southern Russia, skirted the north slopes of the Carpathians, thence northward to Esthonia and across the Gulf of Finland into the land of the present republic. The modern Finns have lost much of their orientalism, yet retain enough to enable even the casual observer to appreciate it. Those of northern Finland, especially, show the broad head of the Mongolian with slant eyes, high cheek-bones and square-set jaws. The language is unrelated to any other European tongue excepting that of the Magyars, and then only to the extent of perhaps a dozen words. The Finnish mind moves slowly, cautiously and deliberately. The Finn listens to argument but reaches conclusions at his own leisure. He is not to be hurried; he is phlegmatic; he is thorough. During long residence in Europe the Finns have come successively under Swedish and Russian rule, and in their trade with the world they have felt German, English and some French influence. With this sort of background how could any one believe that the Finn can be approached in the same manner as the German, Italian, Russian Jew or Greek and be met with any degree of success.

The Finn is suspicious, self-reliant and independent—characteristics resulting from isolation upon the farm where he knew not whether the approaching party was friend or foe. He seeks no help and he takes his reverses philosophically. Charity is repulsive to him and patronage meets with resentment.

Employers in the large industrial plants say that the Finn is uncomplaining. They wish he were not so, for occasionally they do him an injustice. He accepts their verdicts without argument and seeks other fields to conquer. This characteristic certainly operates to the Finn's disadvantage, for when he is dissatisfied with working conditions he simply quits the job, whereas a complaint registered or suggestion offered might readily result in improved conditions. A neat case in point is that of the experience of an employment manager in a factory where upwards of 5,000 men are employed, some 400 or 500 of whom are Finns. In certain of the manufacturing processes the workman is exposed to continuous high temperatures. The foreman was impressed by the fact that when the Finns were put on this job they remained only a

few weeks. They quit because of the heat. On the other hand Italians doing the same work were permanent. But the latter were not as efficient as the Finns because of their lack of sufficient muscular power. By arranging the work of the Finn so that he might have relief from the heat several times during the day he could be retained for months and in some instances a few years. The Finns might have told their foreman in the first place why they would not remain at this work and profited accordingly; on the other hand the employment manager demonstrated what could be accomplished with the immigrant by scientific observation.

Some New Englanders protest that the Finn is unappreciative of the efforts made in his behalf and to prove the correctness of their assertions they point to the fact that when brought together in class groups to receive instruction in Americanism they refuse to sing "America" or the "Star-Spangled Banner."

Analysis reveals the absurdity of the methods of some of the so-called Americanizers in their Americanization work. A direct appeal from a clear sky will not reach the Finn, even though it gets response from other nationalities. Yet this is exactly what has often been tried and found wanting. As previously stated, the Finn is suspicious; he must be convinced of your sincerity and purpose. He is best approached through one of his own people. Hence by gaining the confidence of one of his number, and then through him or with him presenting the appeal, results come forth in rapid succession. Then the Finn sings "America," the "Star-Spangled Banner" and even "My Old Kentucky Home" with all the gusto of the most ardent American citizen. He will do even better than that as witnessed by the writer. He not only will sing "America" in English but will follow at once with the Finnish translation, thus assuring a doubly good job of it.

New Englanders should congratulate themselves that among the numerous nationalities living upon American soil, one at least represents the regeneration of the Pilgrim spirit. The few radicals can be readily eliminated by encouraging them to farm the land, or by carefully and intelligently working with them in other directions, but not by antagonizing them. Many a "Red" has become true blue after acquiring some land and a permanent home. The great mass of Finns give no trouble, but on the contrary are notable for their quiet and modest ways.

What they have accomplished has come about in spite of discouragements. The opportunity to capitalize a new people, if capitalize we must, was never greater than is afforded the people of New England to-day. The responsibility for the right development

of the Finns into a splendid citizenry rests not with them but with the native stock, for they have already shown their metal. Will those who pride themselves in their American ancestry live up to the traditions of their forefathers and lend not a helping hand but a cooperating hand to a worthy people from whom they may actually gain, or will they permit the battleground for American liberty to serve as the site for the development of a social unrest?

BASES OF BRYANISM

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THE attention which Mr. Bryan's latest interpretation of the popular mind has attracted from a group of theologians and scholars who are not wont seriously to notice such productions seems to justify two observations. The first indication is that a belated recognition has come (1) of the lamentably great hiatus that has long existed and has been also long widening between men of science and the unlearned multitude who ultimately, even if unconsciously or involuntarily, support the researches that taken together constitute scholarship and (2) of the retardation of research of every kind by the stealthy pressure of an unsympathetic social milieu. Without asserting that the popular mind stands still, one will not, however, miss the truth far in declaring that every advance by men of learning over the religious and political philosophy of the Revolutionary Fathers has widened the breach between the many who support and the few who promote science—so slow is the task of raising the general level of intelligence. One does not have to fall back purely upon the authority of adages to justify a solicitude for the future of a house thus divided against itself. It is a commonplace to thought that research, of any kind whatsoever, can not fulfill its high mission in a democratic society without a growingly large, even if somewhat dumb, popular approval: without this large ground swell in its direction, research tends either to decline or to become so detached from the common life and aspiration that give it its genesis and justification as to menace while it does persist rather than serve as the organ for popular liberty. For to science also, in the long run, applies the picturesque motto of the French politician, "Walk from the people and you walk into night."

The second observation that seems justified is that Mr. Bryan speaks not for himself alone: he remains what he has for so long been, both the interpreter and the prophet of a great mass of men whose political and religious aspirations find no more commanding articulation. Addressing himself to "the heart and mind of the average man," Bryan speaks for, as well as to, a substantial group of sturdy Americans. Indeed, so far ahead of most public men is Mr. Bryan in responsiveness to popular feeling that one

might suspect that while others still depend upon the old-fashioned and uncertain method of keeping an ear to the ground, Mr. Bryan walks in the garden of human nature in the cool of the day, like the God whose cause he pleads, and by an invisible radio extracts from the twilight zephyrs precisely what common men think and feel. It is this representative capacity of the man that all critics and reviewers perceive and justly emphasize. There is no occasion to exaggerate either the size or the influence of his constituency. It is indeed altogether probable that even as a religious prophet—as a politician he has, you remember, been dead or dying these many years!—he speaks to and for a constantly declining number of people. But that is not to say that he is a voice crying in the wilderness. Throughout much of the west and most of the south—where, be it remembered, there live millions of Americans who still bear children, vote at election time and determine the level of whole systems of education from the common school to the state university—Bryan is read, heard and revered. It is not uncommon in homes where books are numbered by one-and-one rather than by shelves and cases to find Bryan bearing sacrosanct testimony to the inherited elemental philosophy upon which both popular religion and popular politics rest. On a certain modest stock farm in the southwest I recently found shortly after it was issued Bryan's "In His Image," and was cautioned by the owner by all means to read it. This same man, who both in his sturdiness of character and his inherited idea-system represents the pyramid of American society at its agricultural base, had years ago bought and read Bryan's first book of campaign speeches when there was in his home hardly more than one other book, the Bible. And yet he has never shared either the specific religious or political affiliations of Mr. Bryan. Such test cases are at any rate numerous enough to make an analysis of Mr. Bryan's faith an essay in the motivation, the belief and the action of the common man. The growing recognition of the importance for the scientific technician and for the future of science itself of the attitudes of this same common man justifies a more careful analysis of the bases of Mr. Bryan's philosophy of life, that is to say of his religious philosophy, than has yet appeared.

II

A reflective consideration of the implications of Bryan's James Sprunt Lectures, entitled "In His Image," will disclose at least three large assumptions that serve as bases for the arguments: (1) a distrust of human nature *überhaupt*, (2) an undisguised emphasis upon human feelings as over against reflection, and (3) an extravagant optimism based upon factors confessedly outside of

human control. Unless these assumptions be considered, the premises of popular arguments may be refuted *seriatim* without seriously interfering with the functioning of the conclusions. Like the hero of a once popular ballad who, when his legs were shot away, fought still upon the stumps, Bryan's arguments bear, too, a charmed life. Really to refute them one must change the over-beliefs from which they secretly draw their vitality; and to chance these conditioning beliefs one must change the basic action-patterns of men, a change that is often best accomplished by, and sometimes only by, a change in occupation. Let us carefully examine this threefold basis.

To assert that Mr. Bryan lacks confidence in human nature and that moreover he capitalizes this distrust as a foundation for his major arguments may seem unnecessarily to fly into the face of patent facts. For Mr. Bryan not only consistently avows a robust confidence in human nature in general but, what is more, in those very representatives of human nature that to most critics seem least promising, *i. e.,* in common men. He surrenders first place to none in his belief that "mankind deserves to be trusted." It is to this "average man" that he addresses his arguments; and it is from this same man that Bryan draws inspiration and courage by which his position is fortified; for the position that he attacks is, as he says, "so unreasonable that the masses have never accepted it." But one who knows Mr. Bryan will not by any such asseverations as the foregoing be misled as to Bryan's real appraisal of human nature. Mr. Bryan's trust waxes great only in small matters: before questions of "eternal" import man's greatest wisdom is utter folly. And such questions are never further away from Mr. Bryan's ratiocination than the back of his head: every spoke of a wheel has a way of ending in the hub. It must never be forgotten that Mr. Bryan is still preoccupied with the soul and its salvation, that his cosmology is of the two-world variety and that the "other" world is transcendently more important in proportion to its invisibility.

Now the important thing about this medieval dualism is the psycho-ethical implications of it. A certain theory of human nature alone is compatible with this inherited view of the world—the theory that human kind is naturally depraved. As once stated, the theory humbled man to the level of one who could not think a good thought nor do a good deed. But even Mr. Bryan would no doubt slightly modify that statement of the theory, though the theory itself he does not renounce. Indeed, he is convinced that "no one will doubt the doctrine of original sin if he will study nature and then analyze himself." This view of human nature involves as an imperative condition for wise living and right think-

ing an alien standard furnished as a supplement to native human capacity. Human autonomy gives place to a religious autocracy. Of course, this dualism, once introduced, logically involves the necessity of a medium of interpretation as authoritative as the original standard, unless the benefit that motivates the theory is to be sacrificed. It is precisely because of the logical impossibility of making an infallible standard available as guidance for fallible men, without some loss of infallibility, that churchmen more enlightened than Mr. Bryan have been obliged to give up this entire medieval inheritance. But Mr. Bryan wars upon his more intelligent brethren purely because the logical difficulty which they have honestly faced is too profound to catch his attention. There is, however, personal extenuation in the fact that Mr. Bryan has long specialized, not in logic, but in oratory. It is precisely because of this radical distrust of human nature that Mr. Bryan lays hold with such an unrelinquishing hand upon divine aids. And once seized, they are to be trusted all the way. "Bible characters grappled with every problem that confronts mankind, from the creation of the world to eternal life beyond the tomb. They gave us a diagram of man's existence from the cradle to the grave and set up warning signs at every dangerous point."

The chief cornerstone of Bryan's philosophy is thus laid in the Hebrew maxim that "it is not in man that walketh to direct his steps." If this is not giving a dog a bad name in order to hang him, it is at least attributing to human nature such a constitution as without further ado necessitates the ministration of the traditional deity. Man's extremity is made, as always, the theologian's opportunity; and no time is lost in capitalizing this human extremity to justify the foisting upon man of a fundamental and thoroughgoing religious authoritarianism. This is a strange doctrine to be enunciated in a democracy by a leading democrat. All philosophers of democracy since de Tocqueville have noted the incompatibility between democracy and any extraneous authority. Mr. Bryan himself is not without a certain vague feeling for this incompatibility. To compensate for the great discrepancy between his religious philosophy of dominance, which is held to be fundamental, and his democratic political philosophy, Mr. Bryan compartmentizes human nature and then finds—such is the deviousness of rationalizing!—that the doctrine of original sin applies less to one department of human nature than to another. While on the whole, man will certainly not do to trust in fundamentals, yet if one can find the right spot in man's nature, he is not so bad after all. And this moral oasis in the desert of corrupt human nature is the heart of man. So much better is the heart than the head, according to Mr. Bryan, that one might be led to conclude that

Eve ate the fatal apple, not because her heart was set upon it, but because she syllogized herself into its acceptance. Indeed, he does not omit to say that "the conflict that rages between the mind and the heart is the one great conflict in every life. Reason vs. faith is the great issue to-day as in Eden. Faith says obey; reason asks, Why?" Thus Bryan leaves no doubt as to which is the Lord's side in this eternal conflict between the mind and the heart. "The heart of mankind is sound;" but "the mind is a machine; it has no morals." And so, as might be expected, "the Bible's proof of God becomes increasingly necessary to meet the agnosticism and atheism that are the outgrowth of modern mind-worship." Let it be made plain once for all that Mr. Bryan wars on agnosticism, atheism, even evolution only incidentally. These are but the foliage; he strikes at the root, and the root of all modern evil is the too high appraisal set upon mind. His quarrel with Darwinianism is motivated here; for, as he declares, "the natural and inevitable tendency of Darwinianism is to exalt the mind at the expense of the heart." "Religion is a matter of the heart, and the impulses of the heart often seem foolish to the mind." "Hearts understand each other." And finally he summarizes in a burst of oratory: "I fear the plutocracy of wealth; I respect the aristocracy of learning; but I thank God for the democracy of the heart. It is upon the heart level that we meet, it is by the characteristics of the heart that we best know and best remember each other."

This superior excellence of the heart presumably consists in the fact that the heart is more amenable to authority than is the mind. Its merit, like that of women under the same philosophy, consists in its docility. As Bryan says, "When we deal with the heart we deal with religion, for religion controls the heart." Ignoring the question as to whether this is a true description of man's emotional as over against his intellectual nature, it seems certain that this explicit bias in favor of the emotional element is one of the strongest bonds of kinship between Bryan and the common man for whom he speaks. Thinking is hard work; verily there is no pain like the pain of a new idea, especially if it be a religious one. Moreover, thinking arises from uncertainty and doubt, and uncertainty is not a satisfactory emotional state in which to be. It seems perfectly clear that Mr. Bryan's aversion to change is motivated in this reluctance to endure the pain of thinking. He is so quick to scent in the air any maturing demand for change that even the evolutionists can not fool him. Brightly detecting the implications of their doings, he declares that "while the process of change implied in evolution is covered up in endless eons of time it is change nevertheless." Turning, however, in the same sentence to the brighter side, he finds comfort in a biblical

statement that, as he assures us, "does not leave any room for the changes however gradual or imperceptible that are necessary to support the evolutionary hypothesis." "Books on biology," as he elsewhere solemnly declares, "change constantly, likewise books on psychology, and yet they are held before the students as better authority than the unchanging word of God." Recoiling thus from the bared "tooth of time," Mr. Bryan glorifies changelessness, as if an unchanging law could be either permanently true or just in a changing world! The way to easy victory over this shamefully transitory world becomes the possession of a strong faith motivated by unquestioned desire; and the criterion for any doctrine comes to be the ease with which it may be believed. This criterion Mr. Bryan explicitly sets forth in the remark that he knows of "no theory suggested as a substitute for the Bible theory that is as rational and as easy to believe." Since ease is for the most part a matter of wont, it is clear that true ideas turn out to be the old ones, and false ideas, new ones. Of ideas, as well as of men, Dr. Johnson spoke with insight, then, in declaring that "all foreigners are fools." And Mr. Bryan does not hesitate elsewhere explicitly to avow that credence and loyalty are due a hoary theory of man's origin as over against a modern scientific account. At the bottom of all this is the simple understandable fact that belief follows desire, follows it the more naïvely and pantingly the more untrained the believer. In spite of the fact that many human desires are frustrated completely and the majority of human desires partially, the existence of strong desires is still considered in Mr. Bryan's theology as of indubitable ontological significance.

It is because desires are taken as self-guaranteeing that common sense, speaking through Mr. Bryan, is extravagantly optimistic about the goal of humanity while being distrustful of human nature itself. Human desire is but an arrow pointing out the direction of the fruition that God will provide. There is truth in this conception but common sense insists upon such a bizarre form of conceiving it as to belie its nature. Extravagant desires are born of abnormally harsh circumstances; the circumstances that make possible the religious desires of common men create also the machinery—gods, theologies, theodicies—to make certain their ultimate satisfaction. Of course the beggars will all ride so long as wishes are horses. There is nothing to be wondered at in this, but there is much to give pause to men of science.

For the simple truth is—so plain that even he who runs may read—that common sense puts its trust in the irrational only because and only so far as the rational has failed it. Where control has been achieved by, or furnished to, the common man, he no

longer relies upon the occult. But where he knows not what to trust, he trusts he knows not what. Where the telephone reaches, the common man depends no longer either upon prayer or telepathy for communication with his loved ones; he telephones. In illness, a cure is ordinarily credited to the doctor; a death, to God. And so throughout: where control is furnished, control is used. The farmer and the unskilled laborer trust the occult and lean heavily upon compensating desires of future rewards; the skilled worker in industry trusts his union. The religious philosophy of the former is no more to be marveled at, and no less so, than the developing irreligious philosophy of the latter. The boundaries of control mark the boundaries of the average man's trust in human nature. Where control stops, distrust of human nature and an extravagant optimism born of reliance upon the boundless irrational sets in as compensation. Being somewhat scantily equipped with such knowledge as enables him to control the real world (evaluate his secretaryship of state in the light of Ambassador Page's letters), Mr. Bryan simply dissipates in the ideal, as may be seen alike in his conception of the destiny that awaits "our ideal republic" and in his conception of the heaven that is to end the career of the saintly man. And as acts Mr. Bryan, so acts the average man. Confidence in rationality can not far outrun the achievements of rationality among those of little imagination. And while there is political control, the common man is not to any large extent in on it. He replies by distrusting human government as a necessary evil and sometimes by refusing to contaminate himself by even so much as voting. Here Mr. Bryan has gone somewhat ahead of the common man, and by so much as he has gone ahead in getting in on the political control that is actually exercised, by so much has his confidence in the ability of men to govern themselves run ahead of that felt by the average man. It is perhaps not without significance that Mr. Bryan's zealous preoccupation with superearthly means of control has grown greater as his influence over his party has declined. But even in the days of his greatest influence the boundary line of Bryan's control stopped at "Wall Street," and so there he builded his bugaboo, the same sort of bugaboo that the average man has builded back at the ballot box. For, as forts mark the boundary line of national control, so do bugaboos mark the boundaries of human control: where light ends, darkness sets in.

III

All this but means that Mr. Bryan has stated in terms of modern relevancy the never-dying challenge to intelligence. What seems to be a complaint at modern theories can most profitably be

interpreted as a wail from inarticulate men that they have not been let in on modern advances. And to this complaint, so interpreted, science can not reply that it is making available labor-saving machines and other devices as fast as they can be perfected. The gift without the giver is bare. Average men must be increasingly let in on the processes that lead to inventions, on the theories of life and the hypotheses of progress, if the products are not to cease. As simple and as convincing as are the elementary observations on which Darwin based his evolutionary philosophy of life—conquering thus, as Dewey so well puts it, "the phenomena of life for the principle of transition"—more than half a century after the general acceptance of this philosophy by men of science the average man remains utterly ignorant of the evidence that has convinced all who have examined it fully. The average man expresses all he knows about evolution in his retort that *you* may claim the monkey for an ancestor if you wish, but as for him, he prefers another line of descent. So aristocratic is the pedigree of the professions that most professional men actually seem to prefer to confer benefits without divulging knowledge of the means by which they come. The average man takes a tonsilectomy or an operation for appendicitis without softening in the least his opposition to evolution! Indeed many a doctor, instead of conceiving himself as an educator, apparently regards himself as having the valuable key to a kind of esoteric knowledge. The customary reticence of medical practitioners is more befitting the magic past of medicine than its high mission in a democracy. In the face of such neglected opportunities, science cannot reply that she is willing to give, but that the common man is not ready to receive enlightenment. Science must take up the double burden of intelligence, not only to sow the seed, but to prepare the ground as well; not only to give, but to reconcile the receiver to the gift. Whatever is not worthy to share is not worthy to hold. We do not sympathize with a "great" artist who can not get audiences. On the contrary, we charge the artist with the double responsibility of creating both his art and his audience. And the scientist can expect no easier berth. Indeed, he must perhaps reconcile himself to a more difficult mission; for in his case there is perchance a greater readiness to accept the holy fires which he steals from the altars and yet to anathematize the altars that produced them. Insofar as this is true, if true, the scientist may compliment himself on having the bigger job. But there is no shirking it. The altar belongs to its fires, even as do its fires belong to the people.

This point will bear emphasis without becoming labored. Science can not reach its goal separated from the people, and yet

science is separated from the people. If one would see how widely, let him turn round and look at the shadows on the wall cast by the passing panorama. Mr. Bryan's dualistic psychology is the reflection: the heart and the head are at outs, and Mr. Bryan allies himself with the heart, as if the heart could arrive without the head! But Mr. Bryan chooses sides because he finds there are two sides and a battle is raging. He chooses the heart because somebody before him has chosen the head, as if the head could arrive without the heart! A dualistic psychology, as well as a dualistic cosmology, reflects a schism in humanity, a deplorable schism which it is the task of wise men to heal. This burden falls primarily upon the scientists, not only because they are the ones who are responsible for it and because they are the only ones who are able to bear the burden, but because also, insofar as only one side can be in the right, the common man is in the right. The emotional life of man *is primary.* Both phylogenetically and ontogenetically the human "heart" has the right-of-way. "All thought," as James Russell Lowell truly observed, "begins in feeling." But the error of the average man consists in wishing to run amuck because he is granted a right to run freely. Since humanity finds itself possessed with intelligence as an effective instrument for the safety and enrichment of its emotional life, the common man must be prevailed upon not to discard what mankind has so hardly won and so badly needs. Science must humbly reinstate itself as the instrument of humanity's desires—

> That mind and soul, according well,
> May make one music as before,
> But vaster.

The needs of humanity render this no more imperative than does the perpetuation of science itself. And since intelligence does exist as the instrument of human need, intelligence must save its life by losing its pride. The impasse in which all such argument seems to end ought to become a standing challenge to wise men; for if science can not live with the average man, it certainly can not live without him. This is the dilemma that betokens social progress, for in its resolution the average man ceases to be the common man.

THE PLACE OF THE SYSTEMATIST IN MODERN BIOLOGY

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IT is related in the Book of Genesis that all the animals were caused to pass before Adam and Eve and that our progenitors gave to them names. Relatively speaking, it has not been so very long since biology has emerged from what we might speak of as this Adamic period, the period in which the chief, if not the only, interest of the naturalist was to give names to as many as possible of the animals and plants that he had seen, or of which, perhaps, he had only heard. When an organism had been provided with a scientific name accompanied by a few words in Latin that purported to be a description of its chief characteristics it was labeled as "known." And even to-day a very large proportion of our animals and plants are "known" only in this way.

Now, after all, naïve as this may seem, it is not so very different from what we find in other fields of scientific endeavor. The belief that when we have once given a thing or a phenomenon a name we have gone far toward understanding it has not yet been relegated to the limbo of such other superstitions as a belief in the efficacy of charms and the influence of the moon on the growth of potatoes. Men still—at least some of them do—speak glibly of enzymes and vitamins and tropisms and other phenomena as if, now that they have names, we really know what they are and not merely how they behave. A salmon swims upstream to spawn because it is positively rheotropic—a sufficient explanation!

Nor can it be denied that in this mere naming and describing of species there was much of value. Through it men came to know of the richness and diversity of life. Through it we have been made aware of many of the facts that have led to the attempts to explain the origin of species. It has furnished us with the background from which our modern biology has emerged. Yet this naming and arranging of species is not now and for many years has not been the chief end and aim of biology. Morphology, embryology, cytology, physiology, genetics, biochemistry, each in its turn has entered the field and for a period has held its place in the spotlight of interest. Systematic biology has been pushed farther and farther to the side until it has come to occupy but a minor

place in progressive biology. In fact, there are those who would say—and do say—that it is no longer worthy of the serious attention of any one who aspires to the dignity of being called a scientist. Its day is past. It no longer has anything to give us. It is a task merely for the cataloguer, for the individual who, perhaps because he is incompetent to do anything else, spends his time poring over musty volumes and digging up long forgotten names with which to confuse the worker in other fields.

Now I profess to be a systematist—in other words, my chief interest in biology happens to be centered about the task of trying to find out how many and how various are the species of certain groups of insects, of attempting so to describe and figure these insects that others may be able to determine whether they too are dealing with the same species, of so arranging these species in groups of varying rank as to indicate their probable degrees of natural relationship. Incidentally the giving of names to those species that do not now have them is involved, as is occasionally the changing of names already given. In the light of the opinion of the systematist that is sometimes voiced, how am I to justify myself for spending my time in such a task when the whole great field of genetics, let us say, lies open before me? How am I to maintain that faith in the value and dignity of my work that is necessary to the peace of mind of any conscientious laborer?

A very simple answer and one that generally satisfies me, at least, is merely that I like to do these things and that I care not a single good loud whoop whether any one else approves of it or not.

But such an answer is not likely to convince a sceptic of the reasonableness of my position—and I must admit that there are times when it is not sufficient to convince myself. I must occasionally stop and inquire into the basis of my faith. There follows the argument with which I succeed in convincing myself that my work is not wasted.

First, let us consider what systematic biology is not.

It is most emphatically not the poring over of musty volumes and the resurrecting of old names that some—unfortunately some systematists—seem to think. It is not merely an endless quibble over the rules that are to be followed or whether any are to be followed at all or whether this name is to be regarded as having been published within the technical meaning of the term or which name has priority over which or whatever it may be that systematists find to quarrel about. These are but side shows, although recalling a famous controversy that raged for months in one of our entomological periodicals, one might be tempted to remark that they are sometimes a circus in themselves.

These things are no more systematic biology than bookkeeping

is business. Bookkeeping is merely an indispensable adjunct of business and rules of nomenclature are merely a more or less indispensable aid in taxonomy. We may regard bookkeeping with impatience as did the country banker of whom this story is told. The bank examiner in going over his establishment found a drawer containing some cash of which there appeared to be no record. He inquired about it. "That," said the banker, "is my odds and evens drawer. When my books come out with too much money I put it in here and when they come out behind I take it out." Still, however impatient we may be with such small details, whatever our contempt for the bookkeeping type of mind that can not forget the odd cent even when dealing with sums amounting to millions, the fact remains that a certain degree of care in such details is highly desirable. These things are a part of the rules of the game and there are but few games that can be played entirely without rules.

Neither is systematic biology the mere giving of names to species "new to science." To be sure, that is a part of it, for even at this late date there are probably more organisms that do not have names than there are that have. Consequently, this discovery and naming of new species that have not been named is frequently necessary, for it is difficult to discuss things for which names are lacking. I would not deny that there is a certain amount of pleasure in thus bringing to the attention of the world something that no one has ever seen before, in holding up as it were the mangled remains of some almost invisible insect or microscopic plant as a justification for exclaiming, "See what I have found." There are, it is true, systematists who seem to look upon this as the end and aim of their work, like the young man who wrote to a professor of entomology saying that he had always wanted to describe some new species and asking if any were available that he might have. Yet we may dismiss these individuals, as the young man was dismissed, summarily and without regrets.

If these trivial things be not the aim of systematic biology, no more is its aim the grandiose one of solving the problems of the universe. At least I do not think there are many systematists who delude themselves into thinking that they are solving any such problems. Systematic biology can not explain the nature of life or of its processes. It can not explain how species originate or how they are perpetuated. It can not, at least as practiced by most systematists, explain even what a species is. If these things are to be explained at all it must be by some other method of approach, in the end, I suppose, by the methods of biochemistry.

What, then, is systematic biology? What can it do? What

significant contribution can it still make to the progress of biological understanding?

As I conceive it, it is a serious attempt to discover, to describe and to arrange the facts of nature that have to do with the number, the characters and the relationships of all those indefinable groups of individuals that we speak of as species and to present these facts in as clear, as definite and as understandable a manner as may be in order that they may become available to all students of biology in whatever field they may be engaged. It of necessity involves the study of morphology and anatomy. It may utilize the methods of the geneticist. It may call often upon the physiologist and even in extremity upon the chemist for aid in solving its problems. As thus defined it undoubtedly involves far more than many systematists will be prepared to admit, a fact that disturbs me not at all.

As an independent field of investigation it can throw much light on the question of what happens to species after they have once become established. The whole great series of problems involved in the question of geographical distribution with the attendant conclusions and speculations as to places of origin and roads of dispersal of species and larger groups is approachable only by the methods of the systematist. Paleontology is but little more than pure systematic biology, and whatever its contributions to scientific theory may be they are the contributions primarily of systematists. The ever-fascinating problems connected with the study of ancient man and of human origins are essentially nothing more than problems in systematic mammalogy. Whether the "Piltdown man" was a man or merely a chimpanzee, the place of the Trinil man in evolutionary theory, these are nothing more than problems of the systematist working as a physical anthropologist.

Aside from this independent field with its independent contributions to biological theory, systematic studies are the fundamental basis of practically all applied biology and of a large part of the remainder. Discrimination between species—this is the starting point of the majority of our problems in biology. The ignorance—or the ignoring—of this fact is sufficient to invalidate and has invalidated much biological work.

As an example of the effect of poor systematic work on biological theory let us consider the case of certain scale insects. It has been asserted that the females of a small group of species are seasonally dimorphic, and in an attempt to explain this supposed fact an author has advanced the theory that the dimorphism is due to retarded metabolism in the winter forms. No such assumption is necessary, for the plain fact is that the authors who were responsible for the statements concerning this dimorphism had simply failed to discriminate between two or even more species that

chanced to be feeding upon the same host plants. The work of a recent author who has dealt with the very interesting subject of caste formation in certain social insects is at least open to criticism and may even be quite invalidated by reason of a failure to recognize the fact that two closely related but nevertheless quite distinct species were present in the material examined.

In the practical field of economic biology we have even more striking examples of the necessity for care in the basic systematic work. Of three mosquitoes differing so little that the ordinary observer would scarcely distinguish them—they all bite with equal viciousness—one will transmit yellow fever, another will transmit malaria, and the third will be entirely harmless except for the transient pain of its bite. It is said that of perhaps a hundred species in the malaria-carrying mosquito genus *Anopheles* less than half are capable of transmitting the disease. And the habits of these species are as different as their potentialities in disease transmission. Yet the majority of these species are probably recognizable only by a specialist. The need of careful systematic work upon them should be obvious.

Of the hundreds of species of scale insects that are known, but a few are of any special economic importance. These few are in some cases scarcely distinguishable from others that are of no importance whatsoever and the specialist is constantly called upon to furnish the non-specialist with identifications of material.

A striking example of the importance of a systematic knowledge of insects has recently appeared. A weevil found on potatoes in the southern states was identified by the specialists of the Bureau of Entomology as a species that had evidently been introduced from South America. It was found further that it had also been introduced into Australia, where it had become a serious pest. With the knowledge of these facts we are at least forewarned as to what we may expect the insect to do in this country.

Especially in attempts to control insect pests by introducing their natural enemies is there a need for this kind of work. Most of our insect pests have been introduced from foreign countries and are pests here simply because they have left their natural enemies behind them. The problem of finding their natural enemies is first of all the problem of finding where the insects came from, and the answer to this depends upon the identifications of the systematists. Whether the insect that has been introduced is the same as one that occurs in Africa or whether it is one that is found only in Asia—upon the answer given by the systematists depends the direction in which the searchers for its natural enemies will go.

In parts of our western states the pocket gophers are a serious menace to crops. I am informed by one who has been engaged in the practical control of these rodents that it is first of all necessary to discriminate between the various species. Each species has its own peculiar habits, and the poisoned bait that is effective with one will fail entirely with another. So it is throughout the entire field of applied biology, the services of the systematist can not be dispensed with.

It is true that a very large amount of systematic work can not thus be correlated with any special problems of economic or philosophical importance. Yet because of this are we to say that such work must not be done? Who is to say just what work is likely to prove of value and what is not? Who would have thought that any practical benefit could ever come from a knowledge of the various species of sphagnum moss that occur in our peat bogs? Yet during the late war, when it was found that sphagnum moss could be used as a satisfactory base for wound dressings, this knowledge became necessary, for it was found that not all species of this moss were equally useful and a recognition of the species was essential to their proper utilization. I can not believe that apologies are necessary for studying any organism, however obscure it may seem.

On the other hand, there are certain valid reasons why the systematists may in some quarters be regarded with scorn. For one thing, it is a plain fact that much systematic work has been inexcusably bad, so poorly done indeed that it can not possibly be of use to any one. Nor does such an accusation apply merely to the work of the older authors. I have seen descriptions of recent date, in entomology and in botany, at least, that will not permit even an approximation to an identification of the species that they purport to describe. I have seen descriptions that violate every rule of ordinary common sense, and such descriptions are being published to-day in a certain field of entomology.

Another fertile source of distrust is to be found in the purely nomenclatorial wrangles and changes of which I have spoken. Undoubtedly in these there is often much that is trifling, much that is pedantry, much that is actually harmful. Yet here the case is by no means one-sided. A part of the fault certainly lies on the side of those who are not systematists and who have never troubled themselves to acquire the viewpoint of the systematists. To them a change of name is merely an annoyance, regardless of the reasons for making it. To them the splitting up of some long familiar genus with the accompanying changes in the names of well-known organisms is anathema. It matters not that this genus may have

stood so long simply because no one has ever taken the trouble to give it careful study. Progress in their own field is accepted without question, but progress in taxonomy with its inevitable changes is only to be fought. It is, I suspect, largely from this group that we hear so much of the return to Linnean genera, a phrase that—like the famous "self determination of nations"—will not bear close scrutiny.

Another difficulty is the fact that systematic biology, being perhaps the most primitive form, has always been especially favored by the amateur. Now there is nothing finer than the amateur spirit, and the loss of this spirit is much to be deplored. But although we may admire the enthusiasm that leads some utterly untrained worker, without access to literature and without a background of understanding, to plunge into some group, like the scale insects, that is sufficiently difficult even for the trained worker, we can not but shudder at the results. And there has been much of this sort of thing, especially in botany and entomology. It is unfortunate that the democracy of science should necessitate the giving of equal consideration to the work of the ignorant, the mentally unbalanced and the trained student. It is especially in the field of systematic biology that the evil effects of this are felt. The physiologist or the chemist, having demonstrated that a piece of work is valueless, may push it aside and forget it. By the very nature of things the systematist can not do this—the mistakes of the past remain a millstone about our necks. Some day we may find a way to relieve ourselves of them, but that time is not yet.

What is needed, then, is a realization on the part of the systematist that his work is not an end in itself, but that it is a part of the whole great field of biology, that what he does is of importance to the workers in other fields and that it should be done in such a way that it can be used by them. There is needed a constantly improving standard of work and a more keenly critical attitude toward all work that does not maintain the highest standards. And there is needed on the part of non-systematic workers a realization of the fact that they can not well dispense with the services of the systematist. There is needed a realization of the fact that the systematist is not of necessity and should not be a person of inferior capabilities. In fact, the economic worker should pray that the best minds that are available, except his own, shall busy themselves with the doing of the systematic work upon which he is dependent. We are all striving toward the same goal, a fuller understanding of the multitudinous facts of nature. The place of the systematist is that of a full partner in this striving.

THE CONSERVATION OF THE MARINE LIFE OF THE PACIFIC[1]

By Dr. BARTON WARREN EVERMANN

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THE dependence of commerce upon science is so evident that the relation is easily apparent to every one. The only time when commerce and trade could get along even fairly well with relatively little aid from science was in the early days when the wild, uncultivated natural resources of the country were sufficiently abundant to support considerable traffic. But even in those days "when the world was so new and all," when the land was rich in wild fruits and game; when the streams and lakes and ocean banks literally swarmed with food-fishes of many kinds; when fur-bearing animals in marvelous abundance were found in the forests and along the streams; when the bays, sounds and oceans along our shores abounded not only in fishes of great commercial value, but also in fur seals, sea otters, whales and other important marine mammals that became the objects of great commercial fisheries, science had to be depended upon to navigate the ships and river boats, to direct the pack trains, to locate and capture the animals that were the objects of pursuit and properly to care for the animals and other products when secured.

And commerce has developed and grown and been able to maintain itself only as science has been able to lend a helping hand. Science points the way which industry must travel in order that commerce may live.

In the early days of civilized man's relations to the Pacific coast of America, trade was based quite entirely upon the wild, uncultivated natural resources of the country and of the adjacent sea. In the last decades of the eighteenth century the Russians came to Alaska and down the coast as far as San Francisco. They established permanent trading stations at Unalaska, Kodiak, Sitka and Ross near San Francisco Bay, and a temporary one on the Farallons, in order that they might hunt the fur seals and sea otters which then abounded in the waters of those regions. Only a

[1] Address delivered before the Commercial Conference held at Honolulu, October 26 to November 8, 1922, under the auspices of the Pan-Pacific Union.

little later, in the early years of the nineteenth century, adventurous spirits came from Boston, New York and New Bedford around the Horn to fish and hunt and trap; they came for the salmon of our rivers, the fur seals and sea otters of our coastal waters and the whales that then could be found in abundance from the Arctic Sea to Magdalena Bay. For more than half a century practically the only commerce on the California coast had to do with fur-bearing animals, fish, elephant seal, sea lions, whales and other products of the sea. It was the same on the coast of Lower California. On the coasts of British Columbia and Alaska fur-bearing animals and fish were almost the only objects of trade for more than a hundred years.

Alaska Fur Seal

When the Pribilof Islands in Bering Sea were discovered in 1786 by Gehrman Pribilof, they were the breeding grounds of vast numbers of the Alaska fur seal. The number that then frequented those islands has been variously estimated at from two to three millions. At first the Russians killed them, males and females alike, without any discrimination and without any thought of the future. But they finally began to realize that the herd was decreasing in numbers year by year, and more or less helpful regulations were established which afforded some protection. When the United States purchased Alaska in 1867 the herd was somewhat depleted, but still very large. During the period of transfer of jurisdiction and adjustment great slaughter occurred, but this was soon stopped and the government leased the islands for a period of 20 years (1870-1890) to the Alaska Commercial Company, under terms and restrictions which were fairly effective in conserving the herd. Only males were allowed to be killed; all the females were saved for breeding purposes, and, as the fur seal is a polygamous animal, and as the sexes are born in about equal numbers, the company was able to kill about 100,000 surplus young males every year without diminishing the herd in the least. A similar lease was given in 1890 for another period of 20 years.

So long as killing was confined to young males, the herd could not only be maintained, but there would be a substantial increase every year. In the early 80's, however, certain people at Victoria, San Francisco and elsewhere discovered that, by going out to sea in boats and falling in with the fur-seal herd on its return migration in the spring to the breeding grounds on the Pribilof Islands, they could kill enough to make the business very profitable. This was called "pelagic sealing," and the number engaged in the business increased rapidly and greatly.

When killing seals in the water females as well as males are killed; no selection can be made, as the sexes can not be distinguished in the water. On land the sexes can be distinguished and, under the government regulations, only young males were taken. As killing females destroys the breeding stock, the result was that the herd decreased rapidly until, in 1911, there were only about 127,000 left, as against more than 2,000,000 in 1873. Fortunately, the United States in 1911 was able to negotiate a treaty with Great Britain, Russia and Japan, prohibiting the killing of seals in the sea. This treaty was the result of scientific investigations which showed conclusively that the sole cause of the alarming decrease in the herd was pelagic sealing. All naturalists who had visited the seal islands and made any study of the question were unanimous in this opinion, and the Commissioners at the Fur Seal conference which met in Washington in the summer of 1911 were convinced that the scientific men were right.

Unfortunately, the law of August 24, 1912, giving effect to the fur-seal treaty, contained a clause prohibiting any killing on the land for a period of five years. This was a very stupid thing to do, for a certain number of surplus young males can and should be killed every year, not only without any injury to the herd but to the herd's advantage. As the sexes are born in equal numbers, and as one male to every 35 to 50 females is about the proper ratio of the sexes for breeding purposes, it is necessary to save for breeding purposes only a small percentage of the males. But the Congress refused to take the advice of those who knew most about the question and stopped all land killing for five years; and the then Secretary of Commerce, in his stupidity or stubbornness or worse, pronounced the law "very wise and sound legislation for the protection of our seal herds." So the five-year closed period ran its disastrous course. Thousands of male seals, no more needed for breeding purposes than are all the roosters hatched on a chicken ranch, instead of being killed when their skins were most valuable, grew up into old bulls whose skins are relatively of little value, thus causing a loss, directly chargeable to the man who happened to be secretary of commerce at that time, of between three and four million dollars and an injury to the seal herd that will require many years to correct. This is one illustration of the losses that are sure to follow when those directing industries refuse to listen to the voice of experts.

Guadalupe Fur Seal

It appears not to be generally known that fur seals were once very abundant on certain islands off the coast of California and

Lower California. I have recently looked up some of the old records and I was surprised to find that several of these islands were once the breeding grounds of large herds of fur seals. For example, more than 200,000 fur seals were killed on the Farallons, only a few miles from San Francisco and the Golden Gate, between 1806 and 1913. Many thousands were killed about the same time on or about San Miguel, Santa Cruz, Anacapa, Santa Catalina, Santa Barbara, San Clemente and San Nicolas islands off the California coast, and still other thousands at the Coronados, Guadalupe, the Benitos, Cedros and Natividad off the coast of Lower California.

The total number killed between 1806 and 1820 must have exceeded 400,000. At current prices of fur-seal skins these would be worth more than $20,000,000. The killing was done in the most reckless manner possible, without any regard whatever to the preservation of the species, with the result that the rookery on the Farallons was entirely wiped out by 1834. Not a single fur seal has been seen on those islands since that year, although it is not impossible that a few may be left on one of the uninhabited islands of that group.

It is known that fur seals continued to be killed about certain of the Channel Islands for many years after they were exterminated at the Farallons and at certain islands off Lower California as late as 1892. There is good reason to believe a few still persist about some of the isolated, unfrequented islands whose rocky shores contain caves which the fur seals frequent and in which they may escape observation.

The fur seal which occurred on Guadalupe Island, and, presumably, on the other islands off the coast of Lower California was the Guadalupe fur seal (*Arctocephalus townsendi*), a species distinct from the Alaska fur seal (*Callorhinus alascanus*) and, of course, distinct from the Russian and Japanese species (*Callorhinus ursinus* and *Callorhinus curilensis*). What the species was that frequented the Farallons and the other California islands is not certainly known, as there is no specimen in any museum. In all probability it was the same species as that found on the Lower California coast—the Guadalupe fur seal.

Southern Sea Otter

Another fur-bearing animal that was once very abundant on the coast of California and Lower California was the southern sea otter (*Latax lutris nereis*), a subspecies of the northern sea otter (*Latax lutris*), which is found in Alaskan waters and westward through the Aleutian and Commander islands to the Asiatic coast.

The pelt of the sea otter is the most valuable of that of any fur-bearing animal in the world, the skins often bringing as much as $2,000 to $3,000 each.

The early history of California makes frequent reference to sea otters and sea-otter hunting. Indeed, for many years sea-otter and fur-seal hunting constituted almost the only industry of that coast. Sea-otter hunting began there at least as early as 1786, and the industry developed rapidly. Sea otters were found all along the coast from Trinidad Bay southward. They were particularly abundant about the Farallons, among the Channel Islands and even in San Francisco Bay. They were abundant southward at least as far as the islands of Cedros and Natividad. One early manuscript (that of Vallejo) says "they were so abundant in 1812 that they were killed by boatmen with their oars in passing through the kelp."

In 1812 the Russians began to explore the coast, islands and arms of San Francisco Bay. The records show that they gathered great numbers of sea-otter skins. It is said that in some weeks they killed in San Francisco Bay alone as many as 700 to 800 sea otters a week. In a period of five years they took 50,000, and thereafter they took 5,000 a year down to 1831. One writer says that by 1817 the otter was exterminated from Trinidad Bay down to San Antonio Cove near San Francisco, but that hunting continued more or less actively at various places along the coast further south for many years. Some of the hunters hired Aleuts and bidarkas from the Russians and Indians from Mission San Jose, and did quite a good business for some time.

Particular places where sea otters were taken in large numbers as mentioned in the old records were the Farallons, San Francisco Bay, Purisima, Monterey Bay, San Luis Obispo, Santa Barbara, San Buenaventura, San Diego, Todos Santos and San Quintin; also San Miguel, Santa Barbara, Santa Cruz, Santa Catalina, San Clemente, San Nicolas, Coronados, San Benito and Cedros islands. Even as late as 1914 otters were occasionally killed about these islands, and it is known that a few still persist in certain favored localities.

While some of the early accounts are somewhat lacking in definiteness, and while there are many discrepancies, it is nevertheless clear that both the fur seal and the sea ottter were exceedingly abundant on the coasts of the Californias one hundred years ago. The total number of otters killed between 1786 and 1868 must have exceeded 200,000. At current prices these would be worth at least $200,000,000—a very neat little sum.

For a third of a century the hunting of these two valuable

animals constituted the only really important industry on the California coast. In those years scarcely a vessel came to that coast except for the purpose of trading in furs, and nearly every vessel that sailed away was heavily laden with these valuable natural products of the sea that washes the California shores.

It is equally clear that the sea otter, as well as the fur seal, was hunted in the most ruthless manner for immediate gain. That the killing might be done in a manner that would preserve the species in commercial abundance for all time as natural resources of enormous value seems never to have occurred to those engaged in the slaughter.

Elephant Seal

The elephant seal (*Macrorhinus angustirostris*) is another very wonderful animal that was once abundant on some of the islands of the California coast and southward. It, too, was destroyed in the same stupid way that the fur seals and sea ottters were commercially exterminated on our coast.

Until recently it, too, was believed to be extinct, but an expedition sent out from San Diego last July by the Mexican government and the Committee on Conservation of Marine Life of the Pacific,[2] with the cooperation of the California Academy of Sciences, the San Diego Society of Natural History, the Scripps Institution for Biological Research, the National Research Council and the National Geographic Society, found a very considerable herd on one of the southern islands. It will, therefore, be easy to reestablish this remarkable species as one of our important natural resources of great commercial importance. All that is necessary is an international treaty, rigidly enforced, for its protection.

Whales

The *whale fishery* has ever since its inception more than a century ago constituted one of the greatest and most romantic industries of the world. There has always been a strong and impelling fascination about whaling, and vessels have gone into the remotest seas in quest of these largest and strangest animals in the world. So persistently have they been hunted, and for so many years, that it is scarcely less than marvelous that there should be left to-day a single whale of any species anywhere in any ocean.

But we are now beginning to see the end of the 25 or 30 species of whales and other cetaceans known from the North Pacific;

[2] This is a committee of the Pacific Division of the American Association for the Advancement of Science, functioning under authority of the Committee on Pacific Investigations of the Division of Foreign Relations of the National Research Council.

several species that were once very abundant are now commercially extinct. The California gray is one of the six or seven species of whales that still occur on the California coast. In Scammon's time, 50 to 70 years ago, this whale was found on the coast of California in great abundance; in 1853 he estimated that fully 30,000 whales of this species visited California waters every year. The California Sea Products Company has been operating a whaling station at Moss Landing near Santa Cruz since 1918, and another at Trinidad since 1920, and they have taken only five California gray whales in all these years. The California gray is commercially extinct on the California coast. In the same period they secured 1 bottlenose, 1 sei, 4 sperm, 5 sulphurbottom, 19 finbacks and nearly a thousand humpbacks. It is, therefore, evident that the humpback is the only species of whale that is not already commercially extinct on the coast of California; that it, too, will soon be commercially extinct is equally evident.

Salmon

The salmon of the American and Asiatic coasts of the North Pacific are another of our great but vanishing natural resources. There are five species of Pacific salmon, some more valuable than others, but all very important. In habits they are all much alike. They are all anadromous; that is, they live most of their life in the sea and enter fresh water only to deposit their eggs. After having spawned once they all die, males and females alike; none lives to return to salt water. The eggs are deposited in the gravel or on other suitable bottom, usually in the fall of the year, and usually well toward the headwaters of freshwater streams. They hatch in the late winter or following spring, but not until some time after the fish that produced them have died. There is a period of several weeks each year during which each particular salmon family is represented only by a number of eggs. Both parents are dead and none of the children has yet been born; there are only a few eggs to tide the family over. It is, therefore, evident that *no Pacific salmon ever saw either of its parents or any of its children!*

There never was a greater natural resource in any country than the Pacific salmon, and none was ever more recklessly exploited and destroyed. That the industry has not long since been totally destroyed is no fault of those engaged in the business; only the vast abundance of the several species and their unusual and remarkable habits have saved them from complete extinction. Students of the habits of the salmon many years ago began to sound the warning and to tell the fishermen that their methods

meant eventual and inevitable ruin to the industry unless they changed their methods and curtailed their greed.

But they gave little heed to the warning of the naturalists who had made scientific study of the salmon. When the supply of Alaska red or sockeye began to fail, they turned to the less desirable species, the supply of which they believed inexhaustible; but even these are now decreasing rapidly. The sockeye situation everywhere is very serious; in the Puget Sound-Fraser River region it is most alarming.

Nothing short of an absolutely closed period of several years can restore the marvelous run of sockeyes that once entered those waters. There is no excuse whatever for the present deplorable condition. If the common and uniform regulations proposed by the International Fisheries Commission of 1908-1909 had been put into effect by the United States Congress, as Canada was ready to put them into effect, there is scarcely a particle of doubt but that the sockeye fishery of the Fraser River-Puget Sound region would to-day be equal to that of its palmiest days. But a few salmon fishermen (with votes) from Washington State were opposed to Federal control of the fisheries. So they went down to Washington, D. C., where they were joined by certain herring fishermen, also with votes, from Saginaw Bay. And being voters in this democratic government of ours, they had no difficulty in convincing our Senate Committee that the regulations which the International Fisheries Commissioners had proposed were all wrong, although said Commissioners with expert assistants had spent two years in field investigation and study of the problem.

For illustration, the Saginaw Bay fishermen claimed that the mesh of net proposed by the Commissioners for use in the herring fishery of Saginaw Bay was so large that it would not catch the Saginaw Bay herring. To prove their contention, they brought down to Washington a piece of gillnet of the sized mesh the Commissioners had proposed, and a bucket of Saginaw Bay herring. Two of the protesting fishermen held up the section of the gillnet, while a third fisherman picked up the herring by the tail and dropped them through the net. None of them caught in the net; they all passed through readily. And this was conclusive proof to the Senators that the Commissioners had proposed a net with mesh so large that it would prove utterly useless in catching Saginaw Bay herring. It apparently never occurred to any of the distinguished Senators that a Saginaw Bay fisherman who would have been so stupid as to carry down to Washington all the way from Saginaw Bay any herring that would *not* go through the net would be a very stupid Saginaw Bay fisherman indeed! So these

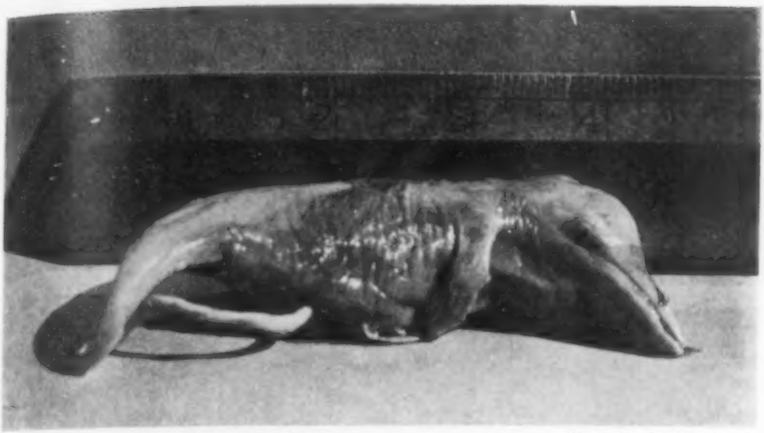


Photo by L. S. Slevin

A six-inch female embryo of a Humpback Whale fifty-one feet long and weighing forty-six tons taken in Monterey Bay, California, May 22, 1922, by the California Sea Products Company.

fishermen from Saginaw Bay and Bellingham with their convincing (!) arguments killed the treaty and, in killing it, they killed the Puget Sound-Fraser River salmon fisheries and the herring fishery of Saginaw Bay.

What I have said about the salmon fisheries of the Puget Sound-Fraser River region applies in almost equal degree to all salmon fisheries in the Pacific—the Sacramento, the Columbia and Alaska. Artificial propagation of salmon has probably done some good in some places; whether it has done any good whatever in Alaska may well be questioned. One outstanding fact, however, is evident, and that is that the methods, regulations and ideals employed in those fisheries must be radically changed if those fisheries are to be restored to, and maintained at, their former productiveness.

Halibut, Herring, Etc.

The halibut, herring and other fisheries of Alaska and elsewhere in the North Pacific are also passing and must receive the serious attention of the various governments concerned if they are to survive.

The Pacific Rich in Natural Resources

The natural resources of the Pacific are the richest and most varied of any ocean in the world. Of marine mammals, I do not know just how many species there are. Recently I was able to compile a list of at least 44 species that occur in the North Pacific: 9 baleen whales, 5 sperm whales, 12 porpoises, killer and dolphins,

From Scammon

Right Whale, the great northern baleen whale of the north Pacific. It attains a length of sixty to seventy feet. It would produce about one hundred and thirty barrels of oil and one thousand to fifteen hundred pounds of baleen. Formerly abundant, especially from Oregon northward, now rare.

a total of 26 cetaceans; and 1 bear, 2 sea otters, 4 fur seals, 10 sea lions, elephant seals and harbor seals, and 1 walrus, a total of 18 carnivores, or 44 in all. There are probably more; I do not know.

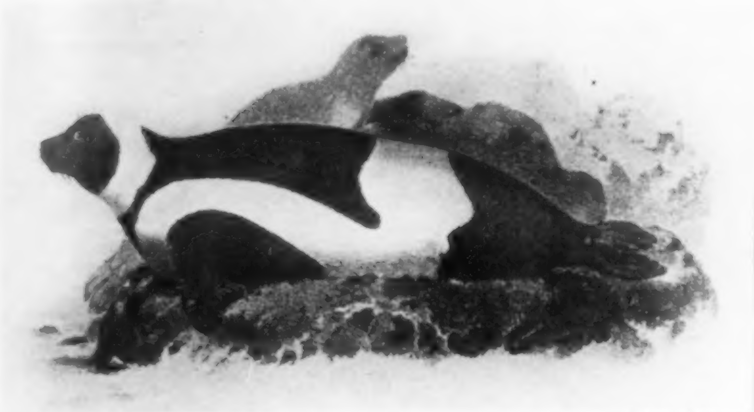
And this very richness of natural resources has made Americans the most shortsighted, the most extravagant, the most wasteful people in all the world. There is not one of these resources which, in the beginning, was not handled in very wasteful ways; in numerous instances so wasteful and so destructive that the resource has been commercially destroyed.

Most fishermen, *not all*, are short-sighted; they lack vision; they conduct their business as if only for the present; they keep the goose laying while the laying is good. But observation points out the inescapable fact that the laying capacity of any goose is limited, and that when that limit is reached there must be another goose ready and able to "carry on," else the golden-egg industry "croaks." Too many business men are ready to milk the cow to the very strippings and then "bump off" the cow.

The paths of industry are paved with the empty shells of natural resources, that, instead of being conserved and made the bases of going concerns, were eviscerated in their infancy.

Productiveness of the Sea Easily Maintained

The natural resources of the sea are very different from those of the land in that they can be renewed from year to year, and, with proper management, kept reproducing themselves indefinitely. Not so with most of the resources on the land. Every ton of coal mined and consumed decreases by just that amount the supply



From Scammon

BANDED SEAL

This beautifully marked seal, of which very little is known, is said to occur on the coast of Alaska and Asia. In April, 1852, Scammon saw a herd of what he believed to be this species on the beach at Point Reyes, California.

of coal in the world, for we know of no way by which to make another ton to take its place. The same is true of gold and silver, copper, and lead and iron; oil, natural gas, and all the other minerals in the world. Synthetic chemistry with these things has not yet reached a commercial basis.

Many of the animal and plant resources of the land must inevitably disappear before the advance of civilization. The existence of great herds of buffalo, elk, antelope and other game animals is incompatible with the clearing up of the country and the cultivation of the soil. It seems impossible to preserve our rivers and smaller streams as fit environment for the food-fishes which once abounded in them. What with pollution of various kinds and other changes in the character of the streams caused by cutting off the forests, draining the swamps and cultivating the soil, it is only a question of time, and not very long at that, when clear, pure streams teeming with delicious food fishes will cease to be.

Nearly everywhere the natural richness of the soil has already become so exhausted that fertilizers must be used to insure any crop at all. Soil experts warn us that, in many regions where irrigation has been carried on for a long time, the soil is becoming poisoned by mineral salts left behind by evaporation and inadequate run-off. The supply of fertilizer in the world, or that can be manufactured, is limited and may be exhausted all too soon, except perchance that which can be made from the animal and plant resources of the sea. As time goes on, the soil will become more exhausted and, consequently, less and less productive, and the

From Scammon

SEA OTTER

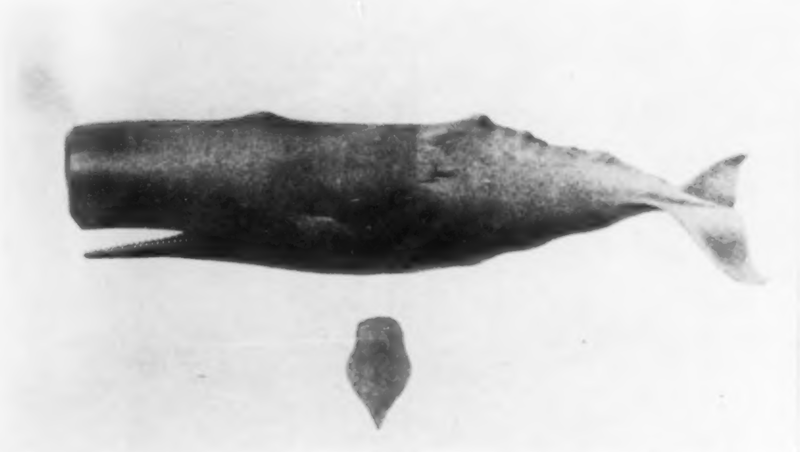
The fur of the Sea Otter is the most valuable of that of any fur-bearing animal in the world; the skins often sell for $1,000 to $3,000 each. About one hundred years ago this animal was very abundant on the coast of America from Bering Sea to Lower California; more than fifty thousand were killed on the coast of California alone, many of them in San Francisco Bay. Those pelts would now be worth more than $50,000,000.

world will have to depend more and more on the products of the sea for its food supply.

So I repeat, when natural resources are considered, the sea is quite different from the land. Man's activities must necessarily gradually and forever reduce and finally exhaust all mineral resources, and permanently and in ever-increasing degree decrease the natural animal and plant resources of the land, and even the fertility of the land itself even to complete exhaustion.

Man can and doubtless will in time so modify or change the land environment that it will no longer be possible for our natural animal and plant resources on the land or the fishes in the streams to maintain themselves in commercial quantities, but he can not greatly change the character of the sea. Old ocean remains unchanged in any vital way, and will, so far as we can tell, always so remain. It is true there is some contamination of the sea by oil from tankers and motor boats, which destroy certain water birds and may do considerable harm to the surface-swimming young as well as the food of some fishes, but this can easily be avoided.

The ocean environment to-day is just as good for fur seals, sea otters, elephant seals, sea lions, walruses, whales, salmon,



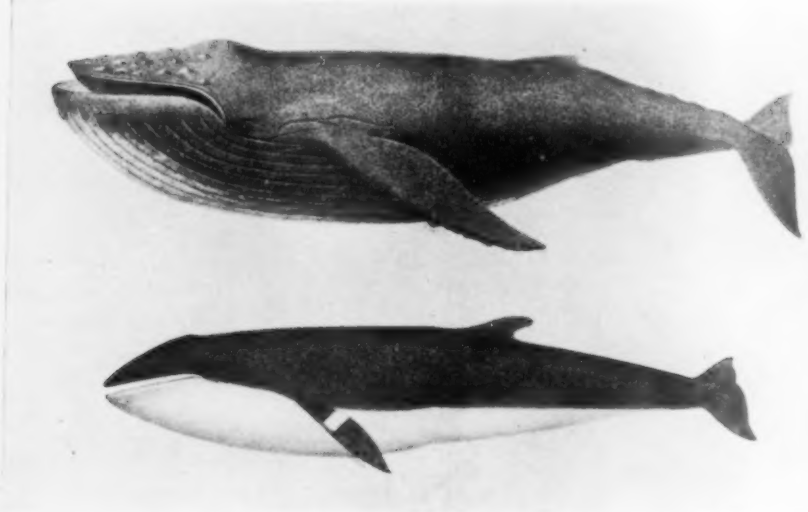
From Scammon

Sperm whales are gregarious, and, before they became so nearly exterminated, were often seen in schools numbering fifteen to twenty, and sometimes as many as one hundred. It attains a length of eighty feet or more.

The species is now very rare on the coast of California, only five having been taken in those waters in four years.

sharks and sardines as it ever was. We do not have to add expensive fertilizer to the ocean to make it produce. The ocean is self-fertilizing; it is kept fertile automatically. Professor Baird and Professor Brooks used to say that an acre of water has a greater productive capacity than an acre of land. I believe the statement to be true. The animal and plant resources, unlike coal and copper, iron and oil, are self-renewing. As I have already said, when a ton of coal is taken out of the mine and consumed, the world's supply of coal is permanently decreased by just one ton; so far as we know there will never again be as much coal in the world as there was before that ton of coal was consumed. Not so with seals, salmon or sardines. Kill a hundred thousand this year and next year there will be just as many as before. Such resources as these are self-renewing.

All that is necessary to maintain the various natural animal resources of the Pacific in a condition that will make each of them the basis of industries of enormous commercial importance is to afford them that protection which will insure a normal annual increase at least equal to the annual kill. Do just that and let nature take its course; that is all that is necessary. But how can that be done? How can we protect the fur seals and the other marine mammals and the fishes so that the species may be restored to, and maintained at, their former abundance, and at the same time permit large commercial catches each year?



From Scammon

HUMPBACK WHALE (*MEGAPTERA VERSABILIS*)
SHARP-HEADED FINNER (*BALÆNOPTERA DAVIDSONI*)

Of the six or seven species of whales that were at one time more or less abundant on the California coast all are now commercially extinct except the Humpback, of which about one thousand have been taken in the last five years. It, too, is nearing commercial extinction.

The Sharp-headed Finner is one of the smallest and rarest of whales. It rarely exceeds twenty-seven feet in length. It occurs from Mexico to Bering Sea.

All of these animals spend more or less of their lives on the high seas beyond the three-mile limit. Most of the killing of many of them, such as the sea otters, fur seals and the whales, is carried on beyond the three-mile zone. On the high seas all countries have equal rights. In the absence of international treaties, anybody of any country has a perfectly legal right to kill fur seals, sea otters, whales or any other animal, and to fish anywhere outside the three-mile limit.

The fur-seal treaty of 1911 entered into by the United States, Great Britain, Russia and Japan protects, so far as those four countries are concerned, the three species of northern fur seals and the northern sea otter north of the 30th parallel, but it does not protect them south of that parallel; nor does it protect them against the nationals of countries not parties to the treaty. There are small fur-seal herds still left on certain islands off the coasts of Mexico, Ecuador, Peru, Chile, Uruguay, Argentina, Australia and New Zealand, and on various islands down toward the Antarctic (South Georgia, Kurgelens, South Shetland Islands, Sandwich Land and others). It would be perfectly legal for a vessel

After Scammon

HUMPBACK WHALES LOBTAILING, BOLTING, BREACHING AND FINNING

The Humpback is the only whale now found on the California coast in commercial abundance. The usual length is thirty-five to fifty-five feet and the weight thirty to fifty tons. During the past five years it constituted more than ninety per cent. of the catch on the coast of California.

flying the flag of any country in the world, except that of the United States, Russia, Great Britain or Japan, to hunt and kill fur seals and sea otters anywhere in any ocean in the world; and it is perfectly legal for a vessel flying the United States flag, or that of Russia, Great Britain or Japan to go south of the 30th parallel of north latitude and kill fur seals and sea otters on the coast of Mexico, Ecuador, Peru, Chile, Uruguay, Australia, New Zealand or anywhere they can find fur seals or sea otters, provided the killing is done outside the three-mile limit. And that this may be done some time is not at all improbable. The only thing that will prevent it is an international treaty for that specific purpose.

I have no doubt but that fur-seal rookeries can be re-established on the Farallons, the Channel Islands, the Coronados, Guadalupe and the Benitos. Such rookeries would in time yield to the United States and to Mexico an annual income of more than five million dollars in revenue. It will be equally easy to re-establish the southern sea otter in California and Mexican waters and that would mean two or three million dollars income to the two countries. The annual catch of fur seals and sea otters in these waters would easily be worth ten million dollars. And the value of the annual product in oil, fertilizer, chicken feed and leather of the whale, elephant seal, sea lion and porpoise fisheries when they shall have been re-established, as I am confident they can, would add several millions more. Then there are the fisheries proper—the salmon, halibut, herring, cod, tuna, sardine and many other species that frequent the high seas and which can be developed to, and main-

An old picture from Scammon illustrating the former abundance of the California Gray Whale. Fifty years ago many thousands visited the California coast every winter. Only five have been taken in the past five years.

tained at, that standard of productivity of which they are easily capable; these would add enormously to the wealth of all the countries concerned.

Mention must be made also of the sea turtles formerly very abundant on the coast of Lower California and on many other shores of the Pacific. Nor should I fail to call attention, if even but briefly, to one other natural resource of the Pacific which has not usually been regarded as of any importance and that is the sea birds. Their value as producers of guano is well known, but the possibility of their ever becoming valued for their feathers and eggs, and as food, has not received much attention. That they will in time be sought for these purposes is certain, and they should be protected for this reason as well as for reasons esthetic and zoological.

The remarkable rapidity with which the Alaska fur-seal herd increased during the last 10 years under the protection of the fur-seal treaty of 1911, an increase from 127,000 in 1911 to more than 600,000 in 1921, which permitted a kill in 1922 of 30,000 seals valued at $1,500,000, demonstrates what a depleted natural resource of this kind will do when given proper protection through international cooperation. The world needs a similar but more comprehensive treaty covering not only the other fur seals of the at present unprotected areas, but the sea otters, elephant seals, whales, walruses, fishes and other natural resources of the sea.

Such a treaty by the various countries of the Pan-Pacific Union and other countries interested would, in a few decades, result in rehabilitating these depleted resources to an extent that would permit for all time an annual product of at least five hundred million dollars.

If these various aquatic natural resources are to be saved, it is important that cooperative action be taken soon by the various countries concerned. An international convention should be called at the earliest date possible to which all maritime countries should be invited to send commissioners to consider the fisheries of the Pacific, or even of the world, in their international aspects. This convention could, with data already available and that can be readily assembled, negotiate a treaty for the protection, rehabilitation, conservation and proper utilization of all the fur-seal herds of the world not already covered by the treaty of 1911. This treaty should be modeled after that of 1911.

This convention could also provide restrictions or closed periods of adequate duration for whales, sea otters and other vanishing species concerning which present knowledge is inadequate for definite and final action as to the conduct of commercial fishing when the species have been restored in commercial abundance.

There are many scientific problems pertaining to the oceanography, meteorology and biology of the North Pacific that must be more fully understood before we can be in a position to say just what regulations will best protect certain of the natural resources of the North Pacific. For example, we do not know (a) just what relation the whales bear to the other fisheries, (b) the best way of protecting the whales and at the same time permitting the whaling industry to continue, (c) the relation of the Orca or killer whale to the fur-seal herd, (d) the relations of the various species of sea lions to the salmon and other fisheries, and (e) the factors that determine the abundance and distribution of marine species, their breeding seasons and places, their migration routes, their food and natural enemies. There are many other problems needing scientific study. An international commission similar to that for the exploration of the North Sea, which has done so much for the commercial fisheries of the North Atlantic, is what I have in mind. A commission like this is needed to secure the facts and figures and other data which will be necessary for full understanding and scientific development and regulation of the fisheries.

What a splendid thing it would be if fur-seal rookeries could be re-established on the Farallons and on the numerous other islands on the coasts of California and Mexico, and on the scores of

islands in the South Pacific and in other southern waters which they once frequented in such marvelous abundance; if we could bring back the sea otter in the various waters in which it has been commercially exterminated; bring back the wonderful elephant seal, the walrus, the whales, other marine mammals and the salmon; learn to utilize rationally the many other natural resources of the sea, and bring about conditions which will enable the industries based on those resources to be maintained as going concerns for all time!

These things can be done. All that is necessary is prompt and intelligent cooperation among the countries represented in the Pan-Pacific Union. I can conceive of no more important movement for the gentlemen of this commercial conference to approve and get behind and urge upon their respective governments.

OBSERVATIONS OF BIOLOGICAL SCIENCE IN RUSSIA

By Professor H. J. MULLER
UNIVERSITY OF TEXAS

IN thinking of his Russian colleague the American scientific worker usually pictures to himself a starving creature in rags, hiding in some attic, where perhaps he may be clinging despairingly to his microscope and to some few remaining books. I found the reality different. The Russian scientist I saw was busily engaged in his laboratory, actively interested in his scientific work and getting results, and desirous above all of getting into touch with the work that the west is producing. At present that is a most difficult undertaking for him, since he can not buy our publications and travel either to or from his country is beset with numberless complications.

These complications affected my visit also, but through the initiative of Dr. Borodin, who is in New York collecting reprints on plant breeding and related topics for the Russian Bureau of Applied Botany, and of Dr. Ivanov, whom I met in England, where he was arranging to obtain material for animal breeding in Russia, I was eventually enabled to obtain the necessary visés to enter the country, and letters of introduction to scientists. Once the lengthy preliminary arrangements had been made, there was no time to be lost, and the journey from Germany by monoplane direct to Moscow was made in about nine hours. To the scientist there any foreign visitor, bearing the longed-for news of the discoveries made in America, is a "windfall," and so I found a most hospitable reception awaiting me from the Russian biologists and was most kindly conducted by them to all the people and through all the institutions that, in my three weeks' stay, I had the time to see.

I found many of the biologists gathered together into a series of large state "institutes," which have developed since the revolution. In Moscow eight of these institutes, including some more strictly medical in nature, are grouped together under the Ministry of Public Health. (See the table listing these and other institutes, in *Science*, April 20, 1923.)

The Institute of Experimental Biology, under the leadership of Professor Koltzof, a man of extremely broad interests, carries on work in various fields—genetics, experimental morphology, ani-

mal behavior, ecology and general physiology. The genetics, under the immediate charge of Professor Lebedof, is carried out at the station of Anikovo, thirty miles out in the country, and near by this is another branch of the institute, the hydrobiological station under Skadovsky. The two together number about forty or fifty scientific workers. At the genetics station some hundred different genes are being studied in chicken crosses. The inheritance of the three sex-linked genes for barring, silvery and short tail is being studied simultaneously here by Serebrovsky, and he has observed crossing-over between them independently of the work of Goodale and of Haldane upon two of these factors, reported in *Science* within recent years. Guinea pig and rabbit crosses are also being made. The latter work, too, is running parallel to what has been found in this country as, for instance, in the case of the finding of a pink-eye-producing, coat-diluting factor like that discovered by Castle a few years ago in guinea pigs from Peru. In the absence of means of communication such duplication is inevitable, and much effort of the highest type must be wasted, to the disadvantage of science in all countries. All the work is not being paralleled here, however. For example, the inheritance of the amounts of enzymes in the blood is also being worked out, the enzymes being measured quantitatively by methods of Professor Bach of the Biochemical Institute. I have not time to describe the various other interesting activities of this station, such as, for example, the biometrical work of Romashof, or the work of Kogan on transplantation of gonads, with rejuvenescence, in fowl, finches and rodents. At this station T. H. Morgan is regarded as the great leader of

FIGURE I. GROUP OF WORKERS AT THE GENETICS STATION AT ANIKOVO. The men from left to right are: Romashof, Serebrovsky, Lebedof, Kogan (sitting) and Shivago.

modern biology, and "The Physical Basis of Heredity" has already been translated into Russian by Lebedof.

The history of the genetics station typifies the terrible struggle against hard economic conditions, rewarded with ever-increasing measure of victory, which many of the scientists have been waging for nearly six years. The land and some buildings were allotted to it in 1919, but practically all the installations, the bringing in of material and the other actual physical construction work had to be carried on by the scientists themselves amidst almost inconceivable difficulties at every smallest step; not least among these was the desperate food shortage, and the construction work accordingly included the setting up of a farm to raise many of their own supplies. They stuck it out, however, and to-day they have not only a fairly reliable food supply, but also serviceable laboratories and breeding houses, with the necessary apparatus, telephone, running water, etc. Whereas in the earlier period they could do little with the animals but to keep the stocks going, they are now finding themselves in a position to do more and more actual experimentation.

It is interesting to observe how the station and its workers derive their support. This comes from a combination of sources, each branch of the government that is interested in the work contributing something, though there is not nearly enough from any one source to run the station. Thus, the Ministry of Public Health, regarding biology as fundamental to it, makes important contributions. The Ministry of Agriculture does similarly. In addition, those members of the station who are at the same time connected with the university receive salaries from there. Quite apart from these sources of support, each scientist draws from the state a certain wage just for being a scientist—which, however, in the case of scientists of the first of the five degrees of eminence into which they are divided amounts to only about $15.00 a month (about half the total salary of many German scientists, but money can buy much more in Germany). And besides this wage in money the scientist draws his monthly *payok*, or food ration. Putting together these various individually very insufficient items of income, the workers at this station seem to obtain enough to cover their most essential needs—of course, not in the style in which these would be taken care of in the still comparatively wealthy countries west of the Rhine, but at any rate sufficiently to enable them to do effective work.

The situation was entirely different from this three years ago. Then, in spite of the attempt at universal *payoks*, the entire city population was slowly starving, and most of the scientific workers lost about 30 pounds in weight. But since that time, despite the still awful famine in the south, agricultural conditions in the

country as a whole are improving and trade is reviving; and this in turn is being reflected in an undeniable improvement in the physical condition, efficiency and hopefulness of the people in general, including many of the scientists.

Though it would be difficult to say just how far the economic condition of these Anikovo scientists whom I have taken as examples is typical of the condition of Russian scientists in general, I met many others living in the city who seemed to be in rather similar economic circumstances. This should not be interpreted as meaning that they were well provided for, according to our point of view, and any assistance which we might render by way of helping to improve their condition could scarcely be better placed, but we ought to realize in so doing that we are helping people who are also actively helping themselves and who are by no means scientifically bankrupt. They are doing work which is well worth while, but which might be still more so if we could lend a cooperative hand at certain crucial points.

It would seem, however, from the urgency of the appeal for aid to Russian scientists issued by Gorki last year that there must also have been other scientists who were in much more dire distress, and those would, of course, have been the very ones whom I would have been least likely to meet. Strange to say, I did not hear of any of these while I was in Russia, although the scientists with whom I spoke were by no means desirous of concealing disagreeable information. In order to get some sort of gauge of the losses that had been suffered by science, I asked the workers at Anikovo what proportion of all those who had been engaged in scientific pursuits in Russia before the war were estimated still to be in the country and at their work. The answer was "two thirds." Of the remaining third, caught in the wars, revolutions and famines, part had emigrated, part were dead and part had left their calling. The proportions of each of these were very uncertain. Naturally, those who had opposed the revolution on the whole fared worse than the others. It should be emphasized, however, that at the present time the political opinion of a Russian scientist is not a bar to his obtaining a position if he has not actively concerned himself with political matters. There seems to be a greater amount of political tolerance now than at any time since the revolution. Though most of the scientific workers have always been anti-communist, yet since the government is attempting to support science, they are becoming workers in state institutions. Thus, Professor Koltzof, although he was in jail for several months three years ago for political reasons and even for a time under death sentence, is to-day head of the Institute of Experimental Biology. Several of the Anikovo workers have a similar

history. When I last saw Professor Koltzof he and his family were living in a well-appointed apartment, with a servant, and he was about to leave for the Crimea on a long needed vacation.

Criticism of the government is very common among the so-called "intellectuals" and seems quite open, but it is not expected that there can be any new overturn. The revolution is universally regarded as an accomplished fact, unavoidably entailing both good and evil, and most of those of all shades of opinion who wish for a political change—whether to right or to left—believe that it can be effected gradually from within. On the whole, however, the scientists whom I met do not actively concern themselves with politics at all; they are too busy with science.

Returning from this digression to our review of the Institute of Experimental Biology, it may be recalled that near the Genetics Station at Anikovo there was the Hydrobiological Station under Skadovsky. This is conducting investigations on H-ion concentration, particularly with a view to its influence on the microorganisms in the water of peat bogs. The position which Morgan occupied at Anikovo is here taken by Loeb, and the two adjacent stations regard themselves as rivals—Morganites and Loebites, respectively.

Koltzof's experiments on animal behavior, urodele development, etc., are being carried on at the headquarters of the institute in Moscow. In the same building are also located the Institute of the Physiology of Nutrition, the Institute of Tuberculosis and that for the Control of Vaccines.

The Institute of Tropical Medicine, under the general direction of Martsinovsky, comprises a large staff and is exceedingly active. Many cultures of protozoan parasites—malaria, trypanosomes, etc., are being propagated and studied. The Leishmann-Donovan organisms, for example, are carried through their entire cycle—both flagellate and sporozoan stages—in vitro. The effects of quinine and various other chemicals upon such cultures is being studied intensively. Entomological and helminthological researches are also being conducted, as well as work of a more directly practical nature, aimed at the immediate control of the diseases. The latter is carried on not only in the laboratory but also by the aid of the attached clinic, through ecological studies in the field and expeditions to all parts of the country. Among the ecological results, for example, is the finding that malaria may be partly controlled by fostering the growth of the common water plant *Utricula*, which has been found to catch mosquito larvæ in large numbers. Finally, there is a department which aims to teach physicians and another to teach laymen through courses, demonstrations, museum exhibits

and literature the best measures of prevention and treatment as found in the theoretical departments.

Many readers will remember that there was an account in the papers last spring of the discovery of the typhus germ in Russia. The finding of this germ—which is now fairly definitely determined to be the cause of typhus—was really made several years ago by Barikin, head of the Institute of Microbiology; and at the same time Barikin found a way of keeping it in vitro for a short while. But last year, with the aid of Dr. (Miss) N. Kritch, he succeeded in getting a method of propagating it in vitro indefinitely. Besides typhus, cholera, plague and other pathogenic microorganisms are being studied by Barikin and his staff. They are doing extensive theoretical work on the effects of selection on their cultures and have succeeded, for example, in changing one "species" of Proteus into another and in altering the agglutinating capacity of cholera organisms. In their immunology department they are making various investigations into the nature of antigen-antibody reactions, the relation between amount and speed of action of antibodies, manner of summation of effects of different sera, etc. Here, too, there is a medical department attached.

The Biochemical Institute of Professor Bach is handsomely fitted up and also has many workers. It is here that the methods were developed for measuring quantitatively the amounts of various enzymes in a single drop of blood, which the genetics station workers are applying in their heredity studies. Professor Bach will also be the head of the large Chemical Institute, the building of which is being erected nearby. This will include about forty chemists and their assistants. The hard economic condition of Russia has prevented any building from being put up in Moscow for the last two years, despite the frightfully overcrowded condition of the city—with this one surprising exception, a building which is to be devoted mainly to the purposes of pure science!

All the institutions have not fared so well. For example, Professor Ivanov, the sperm specialist, who has developed the method of artificial insemination in domestic animals to the point where twenty-five times as many females can be successfully impregnated as through natural coitus, at the same time killing off the pathogenic micro-organisms which may be transmitted in the sperm and thus preventing the spread of venereal disease, says that he can not even get the simple apparatus—syringes, sponges, etc.—in sufficient quantities for distribution to the various animal breeding stations scattered over the country to enable them to reap the practical results from his methods. Things are in a state of flux, not yet sufficiently organized to give with equal justice everywhere.

Professor Lazaref, on the other hand, head of the Institute

FIGURE II. PROFESSOR IVANOV (taken in Berlin, 1922).

of Biophysics and Physics, has been working undisturbed through war and revolution in his magnificent, well-equipped building, built in 1917, two months after the overthrow of the Czar. With his staff of forty skilled scientists and numerous laboratory helpers and assistants, he is directing a system of complicated and coordinated researches into the physico-chemical mechanism of excitation and conduction in protoplasm. Starting out with Loeb's quantitative law expressing the antagonistic action of mono- and bi-valent ions on proteins, he derives curves showing the amount of excitation at the cathode, due to the faster accumulation there of the monovalent faster moving K ions than of the heavier Ca and Mg ions. These and other theoretical curves, including curves of the energy relations involved, he tests out in precise physico-chemical experiments involving the senses of sight, hearing and taste. He finds his hypotheses substantiated and—as one outcome—in the case of all these senses he finds the actual energy involved in stimulation to be the same, as his theory required. He has carried his work further, to the mechanism of conduction of the excitation and beyond that to important theories and experiments on the happenings in the central nervous organs. In terms of the periodical electrotonus which results from the activity of such centers he can interpret various phenomena of reflexes and imitate them in arti-

FIGURE III. A PORTION OF THE INSTITUTE OF PHYSICS AND BIOPHYSICS OF PROFESSOR LAZAREF (taken soon after its construction).

ficial models. The electromagnetic radiations caused by these processes he believes may also be important in causing one center to influence another.

Professor Lazaref was trained originally as a physicist. Only one half of his building is devoted to the biophysical researches; in the rest he directs a series of investigations in molecular physics and photochemistry. Thus he has a great advantage over most biologists when he treats the physical and mathematical problems of biology, and a study of his work should prove of value from the methodological standpoint by itself. Concerning the ultimate value of the results, it would be hazardous to predict precisely. It would be very remarkable indeed if Lazaref's whole elaborate system of theories of sensory and neuron action eventually proved correct in all details, but so much careful work, experimental as well as mathematical, has already been expended on it, that it is bound to contain very important contributions. As the absorbing account of this work was rapidly unfolded to me by Lazaref, the conviction was forcibly borne in upon me that other Americans, could they hear his expositions, would be similarly impressed, and that if Professor Lazaref were to visit this country and give us talks along these lines, our own biological science—or at least that

section of it which could appreciate his work—would be profoundly stirred. Not improbably the shock of contact with this foreign development would stimulate a whole new school of American researches.

There are various other institutes in Moscow in which work of some biological nature is in progress, but of these—the aims of which were often practical or semi-practical, such as agricultural or hygienic—I do not have time for details. Suffice it to mention in this connection only the excellently fitted out Institute of Work, under the physiologist Kekcheyef and the engineer Gastev, which, with a staff of about thirty scientists and seventy helpers, is trying to work out on a scientific basis various acts performed by laborers, to deduce from these analyses the methods of performing these acts that are most efficient from a mechanical, psychological and physiological standpoint, then to find the best ways of teaching the methods to workers, and finally to test them out in the attached factories. Mental testing for occupations and the organization of work is also being studied here. At present the course

FIGURE IV. PROFESSOR LAZAREF, HEAD OF THE INSTITUTE OF PHYSICS AND BIOPHYSICS.

of the hammer stroke is being examined most intensively, and a mathematical formula has been found for the energy changes in the stroke, which has been analyzed by cinematographic records, ergographs and various other means.

Many of the main scientific institutions that are not connected with universities center in Moscow, but considerable work is also being done elsewhere. Unfortunately there was not enough time left to me for Petrograd to enable me to see any institutes there except the Bureau of Applied Botany, under Professor Vavilov—who, as is generally known, visited America last year. Though the offices are in Petrograd, the main genetic work is done on the estates of the former nobility at Tsarskoye Selo, which was the home of the Czar and was the Versailles of Russia. The genetics station building shown in the picture was formerly the mansion of the Grand Duke Michael Nicholayevitch, and had been presented to him by Queen Victoria. The bizarre buildings of the monk Rasputin, given him by the Czar, are also being used, by another group, for scientific agricultural purposes. The genetics station is a center for plant breeding work all over Russia and has over a hundred plant breeders and helpers connected with it in various parts of the country. Vast collections of varieties of food plants—especially cereals—are being made and classified at the station, and they are tested out here on a great scale with a view both to the finding of the best varieties for practical uses and also to the discovery of theoretical principles of variation. Thus Vavilov has found his so-called "law of parallel variations" that the same series of variations occurs in all the species of a group, and after

FIGURE V. GROUP OF WORKERS AT GENETICS STATION OF THE INSTITUTE OF APPLIED BOTANY AT TSARSKOYE SELO. At the extreme left is the director, Professor Vavilov, and on his right, Professor Berg.

classifying the variations of, say, wheat, he can use exactly the same system to represent the variations of rye or barley. Study of the geographical distribution of the varieties throughout the huge extent of European and Asiatic Russia has also led to interesting results and in several cases made it possible to determine the point of origin of a cereal. Besides the more descriptive studies crosses are being worked out, the most important of which are probably those of wheat-rye hybrids.

Professor Berg, shown in the dark cloak in the picture, seeks support in this cereal work for certain rather unique theories of orthogenesis. Embryology, claims Berg, not only recapitulates the past, but to a certain extent predicts the future, which is predetermined within the germ plasm rather than decided by natural selection. It is a curious commentary upon the present situation in Russia that when I mentioned to him the fact that the legislatures of some of our states are seriously considering bills prohibiting the teaching of evolution he countered by declaring warmly that his book, explaining the above theory of predestination, was being held up by his government; publication was stopped and his manuscript being gone over by the authorities, who regarded it as a pernicious and subversive doctrine since it was opposed to Darwinism!

The large research institutes above described do not have a monopoly in research, but of that done by individual scientists in the universities I had less time to learn, except at second hand. There is, for example, in Petrograd University the animal geneticist Philiptchenko, known especially for his work on rabbits and on bison hybrids. Interesting transplantation experiments on hydra, involving grafts from one species to another, have recently been completed by Isayef, also in Petrograd University. The new book on sex and secondary sexual characters, by Savadovsky, of Moscow University, is already known in this country. Madame Nikolayeva, at the Agricultural College in Moscow, has some cytological work, reported to be very interesting, on chromosome aberrations in cereals, which unfortunately I had no time to see. Pavlov is at work in Petrograd, and is supplied with all facilities possible for his research, although I am told that the hard conditions of life of the people in general have affected his spirits, so that he has been unable to work with the enthusiasm of old. For most of the university workers, too, economic conditions are still very hard, as measured by our standards. They are slowly improving, however. So far as their university duties are concerned, there is plenty of time for research work, and this, in fact, is said to be expected of them. I was told by Madame Yakobleva, head of all the universities, that the professors ordinarily lecture between six

and ten hours a week and in laboratory subjects a few additional hours may be spent in the direction of the laboratory work. This compares well with the hours prevalent in America.

In connection with the teaching of biology in the universities, I was rather surprised to be told by one of the prominent younger investigators in a Moscow research institute that this work is still dominated by men of the older school in biology. In Russia, as in most other countries, the majority of the "old line" authorities have a semi-morphological manner of regarding living things. Thus, in spite of the far-reaching changes in educational procedure and in general point of view in Russia, there has, as yet, been no overturn in the manner of teaching biological science, such as is even now taking place in a few of our American colleges where men of the younger generation, with its predominantly physico-chemical viewpoint, have happened to gain the leadership.

It is said that new students are still being drawn into research work in Russia. Of course only a small proportion of those entering the universities ever go into pure science, but it is encouraging to find that more are receiving some sort of education than ever before. This is one of the undisputed benefits conferred by the revolution. It applies not only to the lower sphere of education, which, I was told by Vavilov, has spread so among the ignorant peasants, formerly so largely illiterate, that already the majority can read. According to Yakobleva, there are about 135,000 students in the colleges and universities. Those who wish to and can afford it may go by paying their way, but the majority are sent by various organizations of workers. Although a new movement was inaugurated with the revolution, attempting to make higher education more accessible to all by allowing workers and peasants to attend after passing a preparatory course of only three years, nevertheless four fifths of the students still enter after the regular preparation, as before. Tremendous difficulties are encountered in thus endeavoring to enlarge the educational system amidst the economic crisis and famine. Thus, a new university was started last year in the Crimea. The professors went there, but when they arrived there was no means of existence—no food at all—and professors and students dispersed. Again, last winter the *payoks* arrived late at the university in Moscow; this caused a strike of the professors, and the situation was remedied.

But the most engrossing concern of the Russian scientists whom I met at the present time is neither political nor economic—it is with their work. And the main difficulty of most of them in this now is their isolation: their inability to obtain knowledge of the progress being made in other countries and to exchange ideas with

the west. The geneticists at Anikovo had never heard of East and Jones's book on "Inbreeding and Outbreeding," of Babcock and Claussen's "Genetics," of Lillie's "Problems of Fertilization," of Holmes's "The Trend of the Race." They did not know of any of the American work which partly paralleled their own. They have never seen *Genetics*, and have not seen *The American Naturalist*, *Journal of Experimental Zoology*, *Proceedings of the National Academy of Sciences*, *Science* or *Biological Bulletin* since 1917. Professor Bach, working on catalase, had never heard of Burge. The Institutes of Tropical Medicine and Microbiology are ignorant of all the articles that have appeared since 1919 in the *Journal of Infectious Diseases*, *The Journal of Parasitology*, the *Journal of Experimental Medicine*, the *Proceedings of the Society for Experimental Biology and Medicine*, etc. How can they avoid the most lamentable duplication of work—work that to them involves such costly effort, work at the expense of the finest energies of the nation? How can they build with us, bricks on our bricks, as they ought to?

On the other hand, the Russians, too, are getting results that we should not be ignorant of. Each of the institutes mentioned holds meetings and publishes one or more journals in its lines: *The Progress of Experimental Biology*, *Bulletin of the Institute of Experimental Biology*, *Russian Eugenics Journal*, *Science* (all these edited by Koltzof); *The Progress of Physics*, *Bulletin of the Institute of Physics and Biophysics* (edited by Lazaref), etc., etc. In addition, the institutes and universities publish various other books and separate articles—such as Savadovsky's on sex, Smorodintsef's on enzymes, Barikin's on typhus. I have brought back samples of such periodicals and articles and will be glad to lend them to any scientists interested.

Something should be done to end this state of mutual ignorance. In the first place, in the interests of scientific brotherhood and of science itself, we ought to make our journals accessible to the Russians, for reading at least. The sending of just one or two subscriptions of each journal in its line to that center in Russia which would be most directly concerned with them would scarcely make a noticeable impression on the funds of any American scientific society. At these centers the journals could reach a large proportion of the people interested in them, owing to the peculiar centralization of Russian science in the research institutes. In addition to the sending of journals by societies, I would also urge members to send individual reprints and back numbers of journals. It is most important that these journals should get to exactly the right place—to those centers which do the work in question; for

this purpose they may be sent directly by mail to the appropriate addresses, of which I have published a list in *Science*, April 20, 1923. To be certain to avoid import duty they may be addressed to the institute, instead of to individuals as such.

In the second place, it will enrich our science to know of the foreign work, and we ought to let the Russians know that our journals are available for them to publish in. They are desirous of publishing here, for they see in America now the most important country in which science has been able to retain its old virility undiminished, and our recent biological work is held in the highest admiration. Thus, it would be deemed by any Russian biologist a most valuable privilege were he able to have his results incorporated in our journals with the body of American science.

And there are other media of scientific intercourse besides journals and books. It is remarkable how much just a little personal contact can effect. And it is touching to see how a people so long isolated absorb and cling to each casual word of information which a visitor may let fall. Better than articles, discussion and friendly talk can hit exactly the crucial spots. In illustration of this, I may mention the visits to America in 1920 made by Professors Vavilov and Jaczewsky, which have already resulted in a great rapprochement. But in order to enable these men to obtain permission to travel—from the governments of the countries directly concerned, as well as from those of the countries along the route—it was first necessary for them to receive a formal invitation from a recognized scientific body. In this case the invitation had been issued by the American Society of Phytopathologists to attend the convention of that body, and in view of this invitation the necessary visés were securable. These trips have already had a pronounced effect, which I was able to sense when I was in Russia. For Professor Vavilov, for instance, on returning to his country, had made a special tour throughout the land, giving numerous illustrated addresses to interested audiences of thousands of persons on the scientific work in America. And, on account of this, wherever I went, I found certain general viewpoints and salient features of our American research already familiar, even though the investigators might not have had a chance to read a single American paper. Based on these precedents, further visits might easily be arranged in similar manner by other societies. Various other Russian scientists have been mentioned above who would cover a very different field from that of Vavilov and Jaczewsky and whose talks would be of the utmost interest to us. It is to the advantage, not only of the Russians, but also of ourselves, for us to do what we can to encourage the visits of such men to this country.

THE PROGRESS OF SCIENCE

CURRENT COMMENT

By Dr. Edwin E. Slosson
Science Service, Washington

THE SUCCESS OF A FAILURE

"No," said the lumber dealer, "your boy is good for nothing in my business. In fact, he is the most miserable failure I have ever seen and will never amount to anything."

"Well," replied the disappointed father, "since Emil is too stupid to make a living in lumber, I suppose I might as well let him go to college as he wants to."

So Emil Fischer went to Bonn University to study chemistry. Here he was recognized as one of the most brilliant and industrious students in the laboratory and by the time he was twenty-three he had discovered a key that unlocked one of the most mysterious processes of life. This key was a coal-tar compound known to chemists as "phenyl hydrazine." It was both fortunate and fatal to Fischer. It made him one of the most famous chemists in the world and it brought him disease and death. For the fumes of it are poisonous and constant working with it ruined his health.

But nothing could impair his energy or dampen his ardor. For after he got free from the lumber business and started on his own track, he pursued it for forty-five years without interruption or diversion. As one of his colleagues said at the time of his death in 1919:

> A life is ended in which there was no failure, no let-up in restless activity, no long groping about for something to accomplish. After one quick, clear vision of the goal the path led straight to its accomplishment, a chain of brilliant successes.

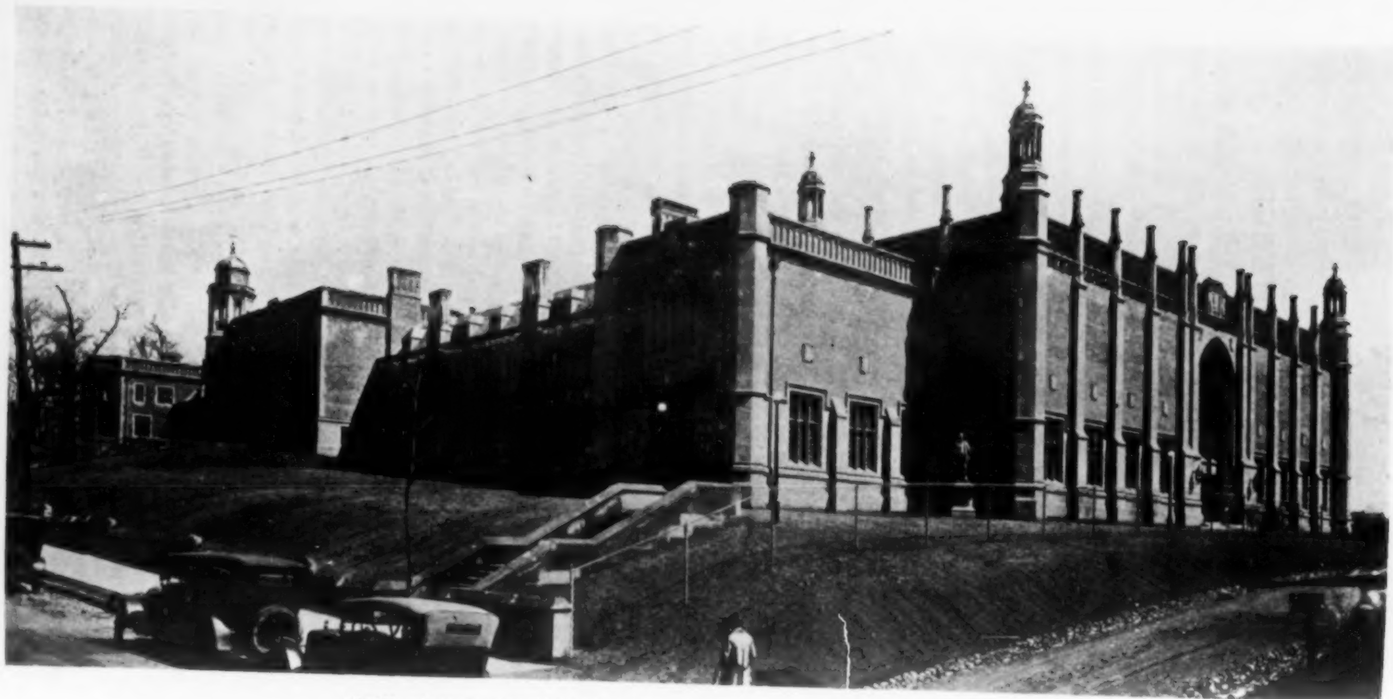
How Professor Fischer himself looked at his life work is shown by these words:

> Still more enticing to some, among whom I include myself, is the hope to climb up out of the valleys to those passes seen afar off, which lead to vast and as yet unexplored countries.

The unexplored country that he had in view and ventured in was no less than the formative functions of vegetable and animal life. With the aid of phenyl hydrazine he was able to solve the secret of sugar. Not content with finding out how sugar may be made by the plant, he learned to make it himself. He found it possible to produce in the laboratory many more kinds of sugar than can be discovered in nature. Finally, he worked out a process by which he could start with plain coal and water and build up a series of edible sugars.

Then Fischer tackled a still more difficult problem in nutrition, the constitution of the proteins. These form an essential part of our food since they contain the nitrogen necessary to all life. It used to be thought that the proteins, whether of vegetable origin like the gluten of wheat, or of animal origin like the casein of milk, were much alike, and that it made little difference which of the many we got in our food. But Fischer showed that a protein molecule was made up of a long chain of carbon and nitrogen compounds and that the links were of very different kinds. Finally, he made a sort of artificial protein, what might be called a laboratory beefsteak, but whether it was good to eat or not could not be determined since there was so little of it and it cost so much. He spent $250 for the material alone, to say nothing of his time in constructing this compound, so, as he said, "It has not yet made its appearance on the dining table."

There is little prospect that the



THE STERLING CHEMISTRY LABORATORY OF YALE UNIVERSITY

One of the world's largest and best-equipped laboratories was dedicated on April 4, in connection with the annual meeting of the American Chemical Society at New Haven.

food of the future will come from the laboratory instead of the field. Even a professor of chemistry can not live as cheaply as a cornstalk. But the work of Fischer on the sugars and proteins has already been of immense value to the world in leading to the newer knowledge of nutrition which is already being applied to the feeding of stock and people.

As Sir Henry Roscoe, professor of chemistry at Manchester, said of Fischer when he was awarded the Faraday medal: "His name has the sweetest of tastes in the mouth of every chemist." Fischer conquered for chemistry a field formerly claimed by biology. He brought within the reach of experimentation what had been regarded as the exclusive province of vital processes.

So it seems that a man may be a miserable failure as a lumber merchant and yet make a success of something else. The problem of education is to fit square pegs into round holes without whittling them down too much in the process of schooling.

THE SUN CURE

OLD Tut-Ankh-Amen, who figures so prominently in our daily press, was brought up as a unitarian sun-worshiper, but later relapsed into the priestly polytheism, which was a pity, for if a people must pick its god from natural objects, as the Egyptians in their blindness had to, it is better to take the sun than to adore cats, crocodiles, hippopotamuses and beetles. The sun is quite literally the source of our vital and mechanical energy, the sole support of all life and motion on the earth, as the ancient Egyptian hymn declares, and we are beginning to recognize, perhaps I should say re-recognize, that it may cure diseases too.

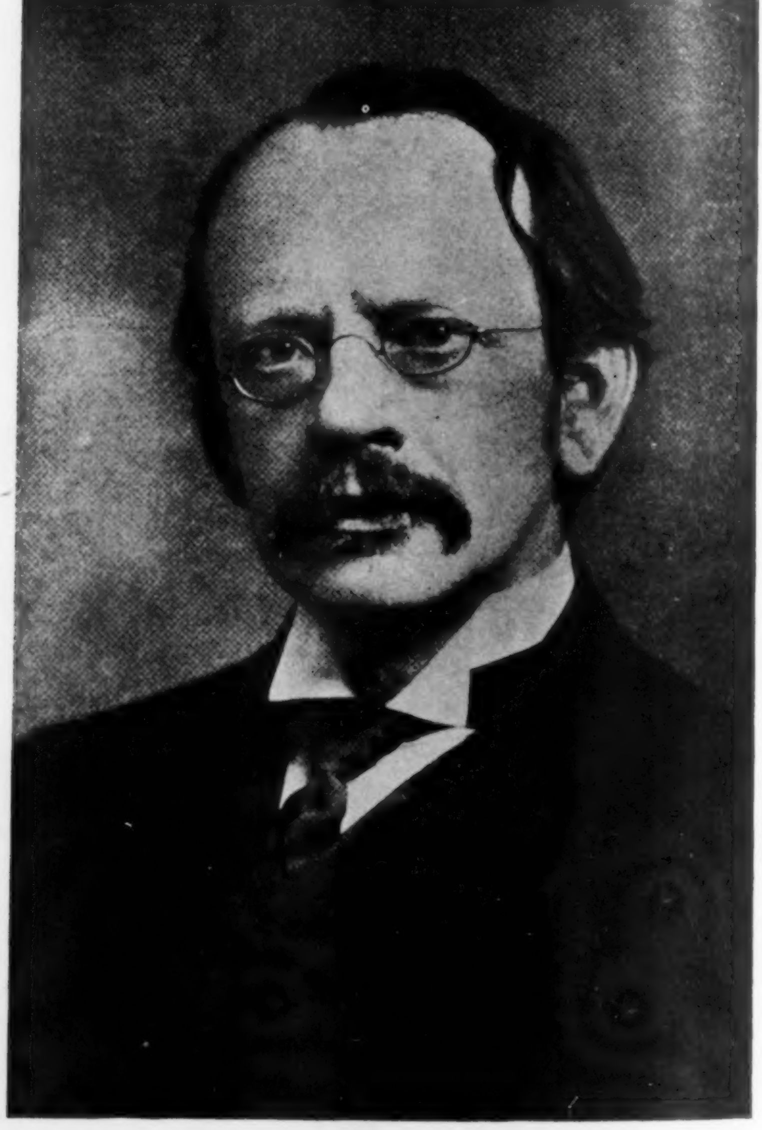
For man has a poor memory. He forgets much that previous generations have learned. The Romans used to make great use of the sun for the healing of sores and the maintenance of health. Pliny, in writing about how his aged friend, Spurinna, keeps his youthful vigor, says:

> When the baths are ready, which in winter is about three o'clock and in summer about two, he undresses himself; and if there happens to be no wind, he walks about in the sun. After this he puts himself into prolonged and violent motion at playing ball; and by this sort of exercise he combats the effect of old age.

But we northern races, having to wear thick clothing and stay in warm houses, get out of the habit of exposing our skins to sunshine. The invention of window glass led us astray, for glass lets through all the light that we can see, and we did not realize that it is opaque to the invisible ultra-violet rays which have the strongest effect upon the skin for good or ill. We thought if we had fresh air and sunlight (even though strained through glass) we had all that we needed from nature.

The rediscovery of the curative power of direct sunshine came by accident. In a hospital for rickety children, it was found that the child who had the luck to lie in a certain cot exposed to the rays of the sun recovered with amazing rapidity. Thorough experimentation, first on white rats, later on children, proved that rickets could be cured either by sunshine or cod-liver oil. There is no question which remedy the children will take if they have their choice.

Dr. Rollier set up a sanitarium on the sunny Alps of Switzerland where the children work and play all day in the sunshine almost naked, and he reports remarkable cures of tuberculous bones and skin troubles. Similar establishments for heliotherapy have since been started in England and America. The treatment of the patients is begun with two minute doses several times a day and increased by two minutes daily for a fortnight, with protection for the eyes and head. It is necessary to avoid both chill and sunburn. Thin white cotton cloth does not seriously shut out the curative rays.



SIR JOSEPH THOMSON
The distinguished British physicist, now master of Trinity College, Cambridge, who has been lecturing in the United States.

The aim is to get the skin tanned without being burned. Brunettes fare better than blonds. It seems that the curative effects do not come into play until the skin is well pigmented by exposure. No tan, no cure. When the skin of the greater part of the body is exposed to the direct rays of the sun, blood pressure falls and respiration diminishes in rate but increases in depth, so the volume of air inhaled is greater. Sunshine striking the skin expands the capillaries and brings more blood to the surface. The number of white and red corpuscles increase and these promote the healing process. The best results are obtained when the skin is exposed to the unfiltered radiation from the sun and yet kept from overheating by a light breeze or bodily movement. In our winter rooms we get the reverse of this, overheating and no radiation.

If sunbathing becomes a fad, it will put the police into the delicate position of having to determine in how far a coat of tan is a proper substitute for clothing.

POWER FROM PRICKLY PEARS

From South Africa comes the encouraging tidings that freedom from the petroleum power may come from the pesky prickly pear. It seems that a farmer in the Orange Free State, who had the misfortune to be infested with the cactus scourge, conceived the happy idea of converting his curse into a blessing by fermenting the fruit into motor fuel. Finding his formula worked he supplied samples of the fluid to his neighbors who used it in their cars and tractors with such satisfaction that the project passed to the stage of public demonstration and selling stock in the Mother Country.

It is stated that land bearing a good thickly thorny crop of prickly pears will yield twenty tons of the fruit, and that every ton of pears can produce thirteen gallons of alcohol. To this is added denaturants and a third of a gallon of an unspecified chemical. Since there are 2,000,000 acres of fertile land infested with prickly pear in South Africa, it is easy to figure out that the annual output of motor fuel should be 350,000,000 gallons, and since South Africa uses only 12,000,000 gallons there would be an abundance to export. And since gasoline costs $1.30 a gallon there and the new fuel is to be sold at 45 cents a gallon, it is a short jump to the claim that "there's millions in it."

To be sure, certain difficulties occur to the reader. For instance, who will gather the fruit from the cactus thicket? It is answered that they will be gathered "at a nominal cost" by the negro children who are very fond of them. But if they are like other children, their ardor for fruit-picking will diminish as their appetite is satiated. I imagine it will be a long time before we hear the wife of the rancher in our own arid region tell the children to "run out and pick a few bushels of pears so your pa can go to town on Saturday."

But whatever the difficulties the process is possible and it is to be hoped that something of the sort will prove profitable. South Africa has to import her gasoline and is already resorting to a substitute called "Natalite," from Natal where it was first used. It is essentially a mixture of alcohol and ether. The ether is manufactured from alcohol and is added to make the fuel more volatile and easier to start from the cold. Natalite, not too offensively denatured, might prove very popular in America as a mixed drink if secretly circulated among our booze-imbibing fashionables at high enough price.

America was most richly endowed with petroleum on the start, but it is a migratory mineral and we lost a lot of it in our haste to get it out and wasted a lot more in our haste

From a Painting by Sir Godfrey Kneller.

SIR CHRISTOPHER WREN

The great English architect, the two hundredth anniversary of whose death has recently occurred. Sir Christopher, who was also a distinguished scientific man, having been Savillian professor of astronomy at Oxford and succeeding Newton as president of the Royal Society.

to sell it. Some day we shall have to resort to a substitute, such as alcohol, which is grown as it is used. In fact, alcohol motor fuels are already coming into use and would be more common if it were not for the restrictions that have to be imposed at present to prevent their use as a beverage. It is to be hoped some way may soon be found to make the legal limitations less bothersome and expensive and at the same time sufficiently strict to insure that the alcohol gets into the carburetor instead of into the stomach.

If so, we may find a use for all sorts of waste materials, including perhaps the prickly pear, though this is not so serious a plague as it is in other lands to which it has been accidently or intentionally exported. In Australia it has multiplied like the rabbits and forms inpenetrable jungles over millions of acres. The government there will lease you 5,000 acres for ten years for a rental of one peppercorn a year, if you will only clear the land of its cactus.

Cactus of all kinds is exclusively an American invention, most ingeniously adapted to resisting drought and warding off eaters. It is not found anywhere else on earth except as it has been carried from this

Drawn by Harry Fenn.

HAMPTON COURT

One of the historical English buildings, of which Sir Christopher Wren was the architect.

country. If you see it in the desert scenes of a biblical movie, you will know that the picture was filmed in Hollywood instead of in the Holy Land, unless perchance the plant has invaded Palestine in recent years.

The world feels a grudge against America on account of the cactus. It is a thorn in the flesh of foreign nations. If now they could make motor fuel from it and so get even with the oil trust, which they also blame us for, they might feel better toward us.

DO THE PAPERS LIE ABOUT SCIENCE?

PROFESSORS as a rule have a poor opinion of the press. They are apt to think that editors are not merely regardless of the truth of the scientific "stories" they print, but that they publish by preference the most absurd and sensational stuff to be found. It is a common faculty saying about newspaper science that "what is new is not true and what is true is not new." It is also a common complaint in pedagogical circles that the newspapers do not pay much attention to science any how, that what little they do publish is antiquated and unreliable, and altogether unworthy the notice of educators.

But it has occurred to two scientific men to apply the scientific test to the prevalent opinion of scientists and see whether it is true or false. Or, rather, to find out to what extent it is true and false, for to the scientific everything is relative and must be measured.

The place where this experimental method was tried was, as we might anticipate, the experimental school of Teachers College, Columbia University, called the Lincoln School, which, although a new institution, has already exploded several scholastic fallacies.

The school has now another such scalp to its credit, for its director, Otis W. Caldwell, in collaboration with Charles W. Finley, has just reported the results of their statistical study of "Biology in the public press," which shows that scientists, in this field at least, have less reason to complain than they thought they

had. Fourteen prominent papers in as many different cities from Boston to Los Angeles were taken for a month and all the articles dealing with biological topics were clipped and classified.

The number of biological articles found during the month was 3,961, and of these only 14 are classed as "fictitious." Four of these appeared in one paper (San Francisco). Of the others, two at least can not be regarded as serious and deliberate attempts to deceive. One is a humorous account of a hoodoo black cat on Halloween and the other tells of a rooster who had been named Harding and taught to smoke cigarets. But I have known very strange things to happen on Halloween, even on the campus, and I have been told by a reputable scientist of a rooster that would eats cigarets, and surely chewing tobacco is as hard as smoking it, especially when one is toothless.

Fortunately the fakes are short. There are 25,596 inches in the total and the fictitious matter only measures 48, so that according to space, one would have to read on the average 500 inches of newspaper biology before he would strike an inch of fiction. Not, of course, that the biologists are willing to O. K. in detail all the other 499 inches. But they say that "gross misstatements of fact were not common," and on many of the dubious points there was room for honest differences of opinion. As for its being antiquated stuff, Messrs. Finley and Caldwell affirm that "newspapers appear to be more up-to-date in things biological than are college and high-school texts in the subject," and in conclusion they turn tables on the teachers by advising them to make use of newspaper articles in classroom instruction, in order to show that biology "is meaningful to the student." The professional nature faker is going out of fashion.

SCIENTIFIC ITEMS

WE record with regret the death of Edward Williams Morley, professor of chemistry at Western Reserve University from 1869 until his retirement as professor emeritus in 1906; of George Lincoln Goodale, professor of botany at Harvard University from 1873 until his retirement as professor emeritus in 1909; of Alice Cunningham Fletcher, assistant ethnologist of the Peabody Museum, Harvard University, since 1882, and of Sir James Dewar, the eminent British chemist.

THE University of Pennsylvania, at a special convocation, conferred the honorary degree of Doctor of Science on Sir Joseph Thomson, master of Trinity College. Sir Joseph, after concluding his lectures before the Franklin Institute, returned to England on April 14 on the *Homeric*.

THE Willard Gibbs Medal of the Chicago section of the American Chemical Society has been awarded to Professor Julius Stieglitz, of the University of Chicago, for his researches in organic chemistry.

PROFESSOR ALBERT EINSTEIN, of the University of Berlin, delivered three lectures in French at Madrid during the first week in March. The King presided at a sitting of the Academy of Science at which Professor Einstein was elected a member.